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SOUTH FORK CLEARWATER RIVER HABITAT ENHANCEMENT

NEZ PERCE NATIONAL FOREST

by

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Nez **Perce** National Forest

Prepared For

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Executive Summary

In 1984, the Nez Perce National Forest and the Bonneville Power Administration entered into a contractual agreement which provided for improvement of spring chinook salmon and summer steelhead trout habitat in South Fork Clearwater River tributaries. The cost of project activity was 1 ,181,730 dollars, and project work was completed in seven main locations: Crooked River, Red River, Meadow Creek, Haysfork Gloryhole, Cal-Idaho Gloryhole, Fisher Placer and Leggett Placer,

Crooked River, in which dredge mining significantly altered channel configuration and left the channel with a lack of habitat diversity and bank cover, benefited from the removal of a barrier; the installation of over 660 pool and cover-creating instream structures; the creation of some 15,000 square meters of juvenile rearing and winter habitat through side channel construction and pond connection; the rehabilitation of approximately 9,230 square meters of flood plain; and the planting of some 30,000 hardwood shrubs and small conifers in riparian areas. Instream structures now account for 37.4 percent of the pools in the Project Area, and in general affected 15.1 percent of the fish habitat (a figure which does not enumerate the positive affects of bank stabilization, flood plain construction and riparian revegetation). Further flood plain rehabilitation would continue to increase the quality of the Crooked River fishery.

Red River, both dredged and heavily grazed, was improved with general bank stabilization; construction of 319 instream structures, 1,548 meters of side channels and 750 meters of fencing; planting of over 11,000 shrubs and trees; and intensive restoration and realignment of 460 meters of river channel. Roughly seven kilometers of Red River would benefit from continued channel restoration and bank stabilization.

Approximately 145,660 square meters of spawning, rearing and overwintering habitat were made available to anadromous fish in Meadow creek by removal of a partial anadromous fish migration barrier. The Forest Service will continue to assess watershed rehabilitation and improvement opportunities in the Meadow Creek drainage to complement the success of the barrier removal.

Finally, construction of sediment traps in the Haysfork and Cal-Idaho Gloryholes prevented at least 1,258 cubic meters of sediment from entering the South Fork Clearwater River system. Revegetation and improved drainage contributed to the stabilization of the gloryholes. There is, however, continuing need to address ongoing sediment production from these sites. Several thousand tons of stored sediment in the Haysfork Gloryhole must be stabilized before check dams decay and fail; a second sediment trap in the Cal-Idaho Gloryhole will be necessary to prevent sediment drainage into Red River when the existing trap is filled; and provision must be made for long term maintenance of all project work.

Among the conclusions that Nez Perce National Forest specialists can draw from the 1 O-year project are these. 1) A fully interdisciplinary approach and a watershed perspective are key to the planning, implementation and success of any major rehabilitation effort. Stream processes are unique to the hydrologic, vegetative and geomorphic properties in the watershed, which must be fully analyzed prior to the implementation of any rehabilitation project, 2) It is necessary to recognize that many rehabilitation techniques, especially fencing, instream structures and sediment traps, require ongoing maintenance. Provision for this maintenance should be clearly defined prior to the commencement of project activity. 3) Like maintenance, monitoring is a process that should be incorporated in initial project planning. Effective monitoring must address specific goals, and be a major element of the project design, 4) Removal of dredge tailings to create flood plains can be an effective way in which to assist a dredge-mined system in regaining natural channel dynamics. 5) Successful instream structures are carefully designed to help return streams to dynamic equilibrium. In these systems, pool creating structures which decreased the width:depth ratios created quality fish habitat without decreasing the streams' ability to flush sediment. 6) In general, revegetation efforts should focus on the reestablishment of native vegetation. We experienced greater success in cuttings made from vegetation already established on the site, and locally grown native varieties, than in exotic or non-native species.

The South Fork Clearwater River Enhancement project increased both the quality and the quantity of anadromous and resident fish habitat in South Fork Clearwater tributaries. Furthermore, valuable experience was gained which will benefit future fish habitat rehabilitation efforts. The Nez Perce National Forest looks forward to future partnerships with the Bonneville Power Administration.

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This report is a collection of the insights of many Nez Perce National Forest specialists. I wish to thank Bill Baer, Kim Clarkin, Klaus Leidenfrost, Kathi Moynan and Wayne Paradis for their extensive assistance and review. Nick Gerhardt, Pat Green, Don Hair, Paul Moroz, Scott Russell, and Rick Stowell also made valuable comments. In addition, I wish to acknowledge Laura Smith for her inspiration in cover design and her patience with the many changes.

In accordance with the Pacific Northwest Electric Power Planning and Conservation Act of 1980, and its mandate to protect, mitigate and enhance fish populations affected by the development of hydroelectric power in the Pacific Northwest, the Bonneville Power Administration (BPA) and the Nez Perce National Forest entered into a contractual agreement to enhance and improve habitats for two anadromous fish species in South Fork Clearwater River tributaries: spring chinook salmon (Oncorhvnchus tshawytscha) and summer steelhead trout (Oncorhynchus mykiss).

Originally, there were two agreements covering activity on the Nez Perce National Forest, Projects 83-501 and 83-502. In 1984, these projects were combined into Project 84-5, which outlined a seven-year implementation schedule for the South Fork Clearwater subbasin, and granted 174,926 dollars. This agreement was amended eight times during the subsequent seven and a half years to include new project activity, to extend the project time-period, and to increase the funding to a final total of 1,181,730 dollars.

The early agreements funded fisheries habitat rehabilitation efforts in Red River and Crooked River. An amendment in 1986 added funding for a barrier removal project in Meadow Creek. In 1987, funding for rehabilitation of several inactive placer mines was included in the agreement. By 1990, project sites included Crooked River, Red River, Meadow Creek, Haysfork Placer, Cal-Idaho Placer, Leggett Placer, and Fisher Placer (Figures 1 and 2).

When the original USFS/BPA agreements were signed, the Forest Service was directed to use the money specifically for habitat rehabilitation activity, not for extensive planning, surveying or monitoring. Concurrent to its agreement with the Forest Service, BPA signed an agreement with the Idaho Department of Fish and Game (IDFG), which directed IDFG to monitor the effects of the project work.

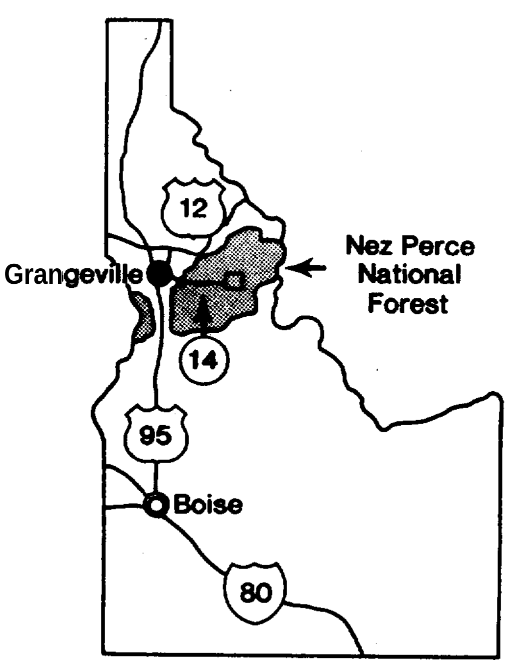


Figure 1. Location of the Nez Perce National Forest.

Historically, there were 9,150 kilometers (km) of stream available to Idaho's salmon and steelhead, which supplied over 10,935 hectares (27,000 acres) of spawning and rearing habitat for each (Mallet, 1974). Due to dam construction, road construction, mining, grazing and timber harvest, Idaho lost 3,750 km (41 percent) of its anadromous stream habitat (Ibid.). The Nez Perce National Forest contains 38 percent of the available habitat acres in Idaho, and correspondingly, the capability to produce about 10 percent of the summer steelhead, and 9 percent of the spring chinook in that portion of the Columbia River Basin above Bonneville Dam (Stowell, unpublished). Production of wild anadromous smolts has been calculated at 331,000 steelhead and 470,000 spring chinook (Nez Perce National Forest, 1987); in an outstanding year, roughly 7,000 wild steelhead might return to the Forest to spawn (Roseburg, pers. comm.). Due to habitat degradation and migration barriers, these numbers are considered to be below habitat capability.

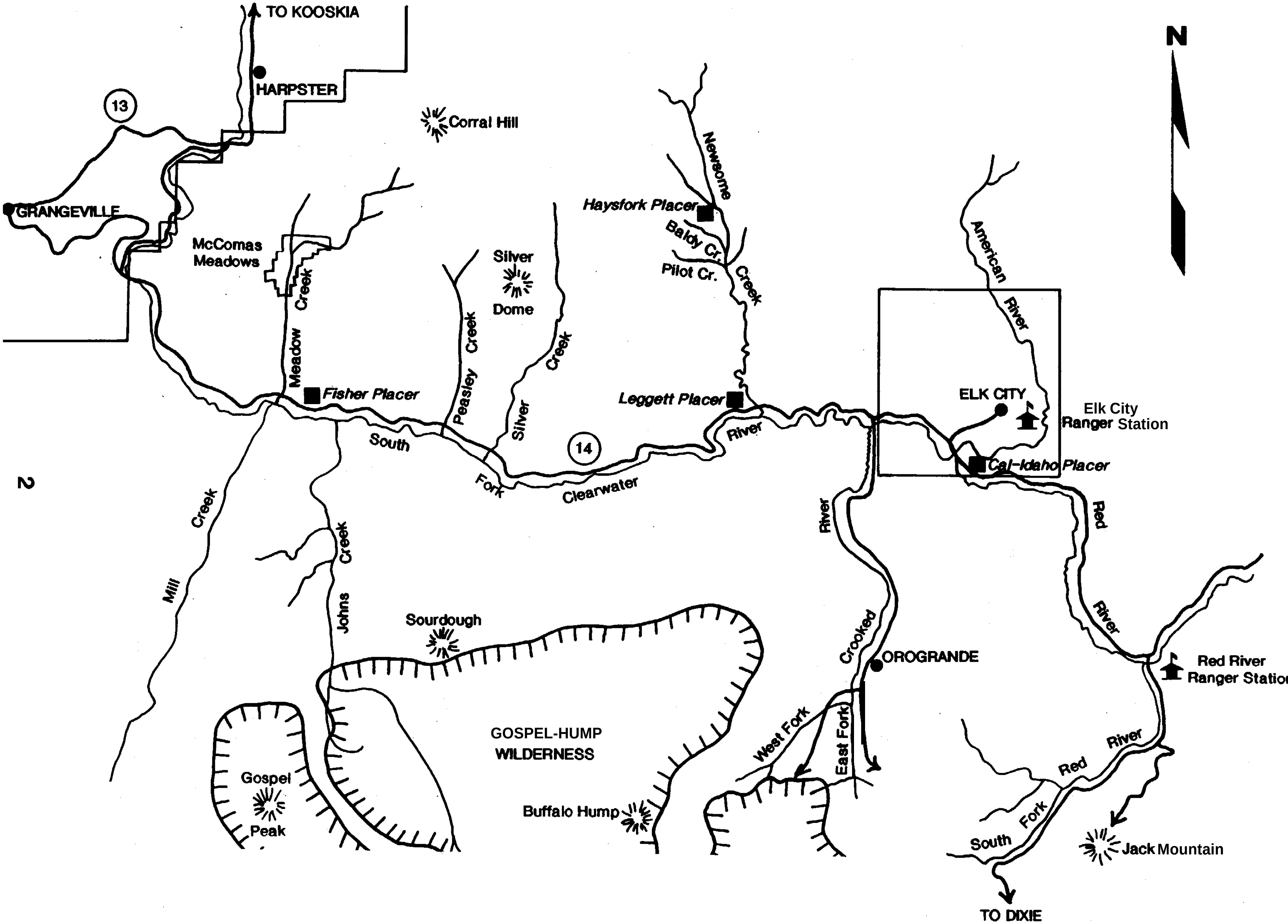


Figure 2. Portion of the South Fork of Clearwater River Drainage, Nez Perce National Forest.

A number of factors have combined to degrade the quality of the anadromous fish habitat in the South Fork Clearwater River. Mining, both dredge and hydraulic, livestock grazing, timber harvest and road construction have resulted in increased sediment loads in the streams, and, in places, have denuded the streams of riparian vegetation. In 1911, construction of a dam in the South Fork Clearwater River precluded anadromous fish passage. A fish ladder constructed there in 1935, and destroyed by high water in 1948 (Parsell, pers. comm.) or 1949 (Idaho County Free Press, 1963), failed to pass significant numbers of fish successfully. When the dam was removed in 1963, anadromous fish runs had been eliminated from the South Fork drainage.

The Idaho Department of Fish and Game began re-introducing anadromous salmonids to the drainage in 1962. Over the next several years, hatching channels were constructed on Red River at the Red River Ranger Station, on Crooked River near Orogrande, and on Meadow Creek (T 30N R 4E Sec 24). Each was stocked annually with various species of eyed eggs, which, depending on the channel, included coho, chinook and/or steelhead. The Crooked River channel was abandoned in the late 1960s; the Red River and Meadow Creek channels have not been used since the late 1980s.

During the summer of 1989, the U.S. Army Corps of Engineers constructed a 1.3 million dollar satellite rearing facility on Crooked River, which is managed in conjunction with the Clearwater Fish Hatchery in Ahsahka, Idaho. The facility includes two raceways, each capable of holding 350,000 chinook smolts, and an adult trapping and holding capacity of 500 spring chinook. No rearing of steelhead is planned, although the facility may be used to trap adult steelhead (McGehee, pers. comm.). A second rearing facility, constructed on Red River in 1977, also serves as a satellite to the Clearwater Fish Hatchery. This facility includes an acclimation pond that annually holds 40,000 to 350,000 chinook fry before they are released into Red River.

To augment IDFG's program, the US. Fish and Wildlife Service (USFWS) began introducing steelhead smolts to the South Fork Clearwater system in the early 1980s, and chinook smolts in 1989. USFWS has released smolts in several locations, including Crooked and Red Rivers. In all, some 700,000 chinook smolts and 7,000,000 steelhead smolts have been released into the South Fork Clearwater system as a result of this effort (USFWS, unpublished).

The Project Areas: Crooked River was extensively dredge mined in the 1940s and 1950s. As a result, bank structure, fish habitat and channel morphology were significantly affected. Long piles of cobble and boulder dredge tailings still are, in places, 15 feet high. The tailings, which are characteristic to a dredge-mined stream, are not without historical interest, and plans have been made to preserve portions of the tailings as the miners left them. Fisheries and riparian habitat rehabilitation, however, requires that the remaining tailings be reshaped and revegetated.

Red River was also dredge mined, although to a lesser extent than Crooked River. In addition, about 50 percent of Red River is privately owned, and has been extensively grazed. Banks along Red River were consistently unstable, and sloughed several hundred tons of sediment into the system each year. Limiting factors to anadromous fish populations in Red River included high sedimentation and lack of habitat diversity.

A boulder cascade in Meadow Creek presented a partial migration barrier to adult steelhead, and a complete barrier to migrating chinook. The cascade prohibited access to approximately 145,660 square meters of spawning, rearing and overwintering habitat in upper Meadow Creek.

Hydraulic mining of placers from before the turn of the century into the 1940s resulted in twenty to thirty large open pits throughout the South Fork drainage. These pits, which are locally known as ‘gloryholes; can be over 15 acres in size, and contribute thousands of tons of sediment to the South Fork system each year. Project 84-5 activity centered on four of these gloryholes, and helped to identity the enormity of the task the Forest will have in rehabilitating these sites.

This report discusses thoroughly the several projects on the Nez Perce National Forest in which BPA funding was utilized. Project activity in each of the areas is described, and where reasonable, results of the activity are summarized. In addition, some recommendations are made for future action.

Section I: Introduction

Gold and silver mining drastically affected between 60 and 121 hectares (150 and 300 acres) of the Crooked River drainage, or about 11 kilometers of the channel. Several different large bucket dredges operated in the river between 1936 and 1958, including the "Mount Vernon Dredge" and a 4 cubic foot YUBA boat dredge (Figure 3). In addition, a small dragline and washing plant operated between Relief Creek and Five Mile Creek in the late 1950s, and recreational dredging has occurred periodically since then.

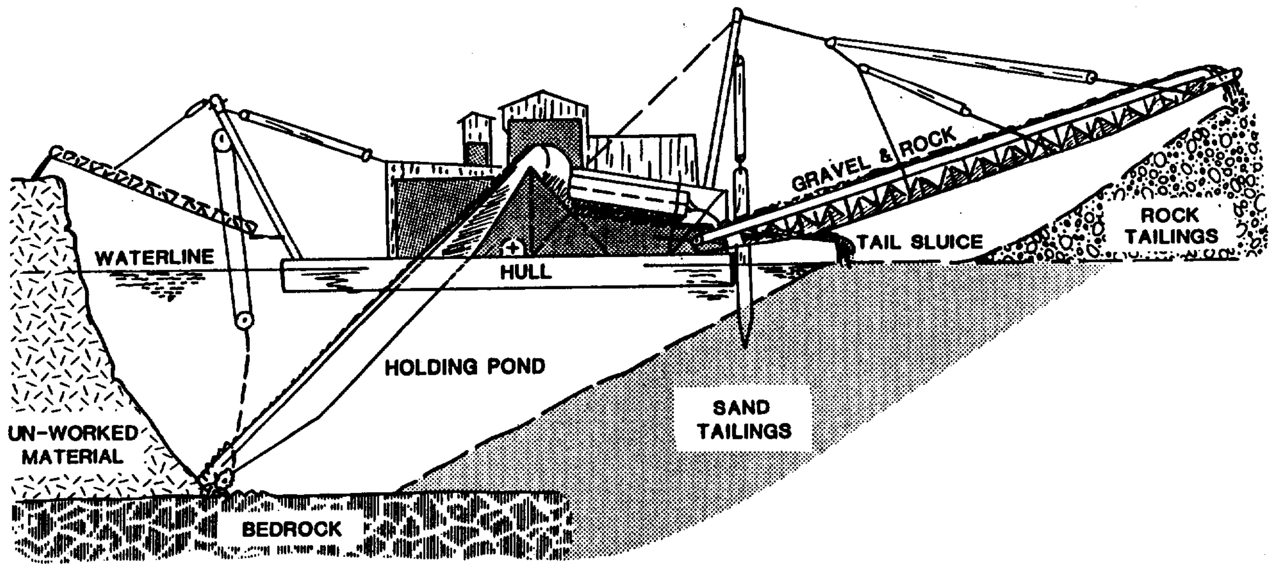


Figure 3. Floating dredge of the type used in Crooked River between 1938 and the late 1950s.

Detailed historical records have been kept of the Mount Vernon Dredge, primarily because it remained on Crooked River, near Fivemile Creek, until 1987. The dredge was built in 1935 at the Washington Iron Works of Seattle, for 37,350 dollars, It was 18 meters in length, and had a 2 cubic foot capacity which enabled it to dig up to 1,530 cubic meters of material a day. It had a one meter draft, and a digging depth of between three and six meters. The Mount Vernon dredge first operated in Crooked River in 1938, and except for a few interruptions, continued to work in the area until the late 1950s. (By law, the dredge was not allowed to operate during the Second World War, and from 1947 to 1952 it operated in nearby Red River and Buffalo Gulch.)

In several of the years that it operated in Crooked River, the dredge ran 24 hours a day with shifts of up to 20 men. It consistently topped annual production in the Orogrande Mining District, and several times ranked number one in Idaho County. It is unclear just why the dredge was abandoned in the late 1950s, but when its operations ceased it had produced 17,000 ounces of gold and silver, mostly from Crooked River. In 1987 the dredge was transported to a museum in Virginia City, Montana.

Crooked River has long been recognized as an area in dire need of fisheries habitat improvement. Rehabilitation of a dredge-mined stream like Crooked River presents some unique challenges. Primary among these are the difficulty in establishing vegetation on loose, cobble tailings piles, and the tendency of the water to flow through the tailings piles in subsurface routes, Because dredging removes large boulders and woody debris from the stream, and riparian vegetation from the banks, limiting factors included a lack of adequate pools, instream cover, overhanging vegetation and undercut banks, and unnatural sediment accumulations in some reaches.

Fisheries habitat rehabilitation projects were proposed as early as 1962, when the Idaho State Highway Department applied for a permit to use dredge tailings to surface area roads. In 1972, 30,000 tons of gravel were removed from tailings about one-half mile north of Orogrande. Apparently, some seeding accompanied this operation. A USFS Environmental Assessment in 1973 detailed an ambitious habitat improvement plan to accompany the removal of 10,000 tons of aggregate by the Idaho State Highway Department. Plans included channel alteration, topsoil distribution and plantings of native shrubs and grasses. Although the gravel was evidently removed as planned, little if any of the habitat improvement work was completed. Five k-dams were constructed near Relief Creek in 1981 (Bruno, pers. comm.); according to IDFG, all of these structures showed signs of deterioration in 1984, mostly consisting of erosion at the banks (Petrosky and Holubetz, 1985).

The first of the BPA/USFS agreements focused specifically on removing a partial barrier from Crooked River. Before long, however, the contract included funding for a more ambitious fisheries habitat rehabilitation effort. Five goals were established: 1) improved habitat for anadromous fish; 2) improved habitat for resident fish; 3) improved riparian habitat for wildlife; 4) improved visual quality of the dredged area; and 5) a proven example of stream rehabilitation suitable for use in other degraded stream habitats.

Section II: Project Area

Crooked River originates on the northeast perimeter of the Gospel Hump Wilderness, and as a fourth-order tributary enters the South Fork Clearwater River at river kilometer 94 (Figure 4). In its entirety Crooked River extends some 27 km in length, and produces approximately 76,300 acre feet of annual runoff from a watershed of some 18,190 hectares (44,914 acres). Flows range from a minimum of 10 cubic feet per second (cfs) just prior to spring runoff to a maximum of 700 cfs during spring runoff. Sixty percent of the annual precipitation occurs between November and April, much of it snow.

The stream is now an important producer of spring chinook salmon and summer steelhead. Other fish species inhabiting Crooked River include westslope cutthroat (O. clarki lewisi), bull trout (Salvelinus confluentis), brook trout (S. fontinalis), mountain whitefish (Prosopium williamsoni), mountain sucker (Catostomus platyrhychus), longnose dace (Rhinichthys cataractae), speckled dace (R. osculus) and sculpin (Cottus sp.). Murphy and Metsker (1962) found 7,279 and 4,202 square meters of suitable spawning gravel for steelhead and salmon, respectively, in Crooked River.

Vegetation: The Crooked River drainage is characterized by a mixed coniferous forest consisting of Englemann spruce (Picea engelmannii), grand fir (Abies grandis), Douglas-fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta), subalpine fir (Abies lasiocarpa), ponderosa pine (Pinus ponderosa), and larch (Larix occidentalis). Riparian vegetation includes alder (Alnus spp.), willow (Salix spp.), red osier dogwood (Cornus stolonifera), cottonwood (Populus spp.) and Rocky Mountain maple (Acer glabrum).

Solls: The bedrock geology is complex and diverse, due to an intergradation of rock types. Quartz monzonites of the Idaho Batholith, and Prichard formation quartzite, gneiss and schists, are the dominant lithologies. The extensive dredging in lower Crooked River removed much of the fine material, leaving an infertile substrate of course fragments which is susceptible to drought because of its inability to hold moisture. Had dredging not occurred, the Crooked River valley bottom would probably have a higher Water table and mosaics of marshy vegetative communities,

Wildlife: Wildlife in the area includes muskrat, river otter, raccoon, snowshoe hare, coyote, mink, bobcat, lynx, black bear, mountain lion, mule deer, whitetail deer, elk and moose. Idaho Department of Fish and Game planted nine beaver in 1968; beaver and beaver sign were encountered during the project. USFS biologists attempted to maximize benefits to wildlife where possible. Several areas of particularly high wildlife use were identified, and intentionally left unaffected by project activities.

Migratory waterfowl which use Crooked River include mallards, pintails, ruddy ducks, teal, baldpates, gadwalls, goldeneyes, common mergansers, Canadian geese, snow geese and whistling swan. A variety of shorebirds, upland game birds, hawks, owls, jays and others are indigenous in varying numbers. Project work is of direct benefit to wild waterfowl and other riparian bird species by having created more natural riparian conditions and increased wetlands habitat.

Project Area and Segment Descrlptlon: A 1987 study by the Idaho Department of Health and Welfare (Mann and Von Lindern. 1988) revealed that flows measured near the mouth of Crooked River were consistently less than flows measured upstream. This indicates that water volume is lost to subsurface flow,

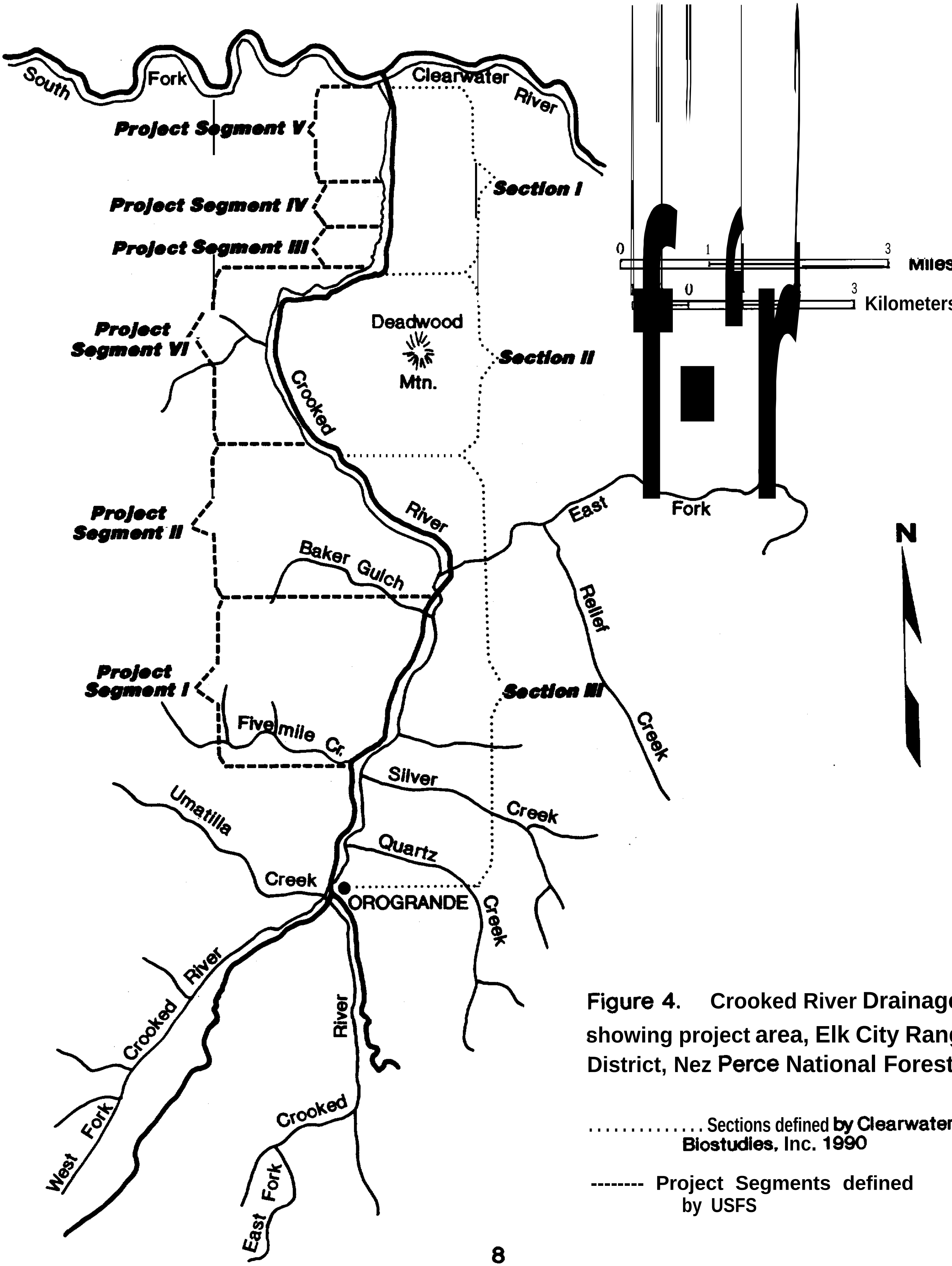


Figure 4. Crooked River Drainage showing project area, Elk City Ranger District, Nez Perce National Forest

.... Sections defined by Clearwater Biostudies, Inc. 1990

-------- Project Segments defined by USFS a phenomenon not unusual in heavily dredge-mined areas. Subsurface flows are clearly visible in dredge ponds adjacent to the main channel.

In the course of the dredging, the fine sands that had contained the gold were deposited back onto the ground first, followed by the cobble and boulder, which compose high tailings piles evident today. Silt, clay and organic matter were suspended and moved downstream. Some portions of Crooked River, where dredge tailings were left roughly parallel to the creek, were straightened by the dredge mining. Lower portions, where tailings were left in rows perpendicular to the stream flow, are now in a series of right angle bends around L and T-shaped piles (Figure 5). In these areas, many small ponds were left in and around the channel meanders, most of which were fed by subsurface flows, and many of which became stagnant during low flows.

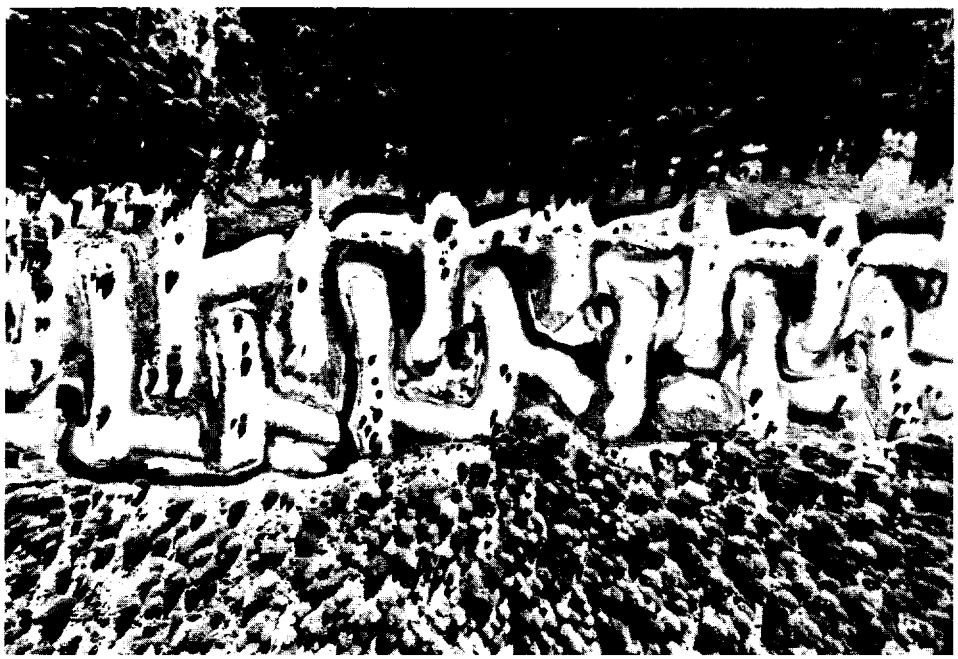


Figure 5. portion of Project Segment IV, where dredge tailings force the river into an exaggerated meander pattern, Crooked River, 1986.

Large woody debris and boulders were removed from the channel during the dredging process, reducing structural habitat diversity. The unstable rubble and boulder composition of the bank has largely prevented the growth of vegetation, and therefore future sources of large woody debris, detritus and shade. In addition, this artificial bank composition precludes the development of undercut banks, and results in the aforementioned subsurface flow.

The actual project area extends from the river's confluence with the South Fork to Fivemile Creek, a distance of some 16 km. This portion of the river was categorized in six segments having similar habitat characteristics (Figure 4). The segments are referred to by number throughout this chapter.

In Segments I, II and III, Crooked River was left in a fairly straight pattern by the dredge mining. In general, one bank is fairly ‘natural,” while the other is composed of loose, cobble tailings piles, Limiting factors included a lack of pools, insufficient instream cover, a lack of shade, and unstable banks. Pre-project surveys in Segments I and II identified a pool ratio of less than ten percent, and showed that instream cover was present in two percent or less of the habitat units.

An improperly installed culvert in Segment I presented a fish passage barrier to migrating adults. High flows in spring blocked the migration of adult steelhead, and low flows in late summer blocked the passage of migrating adult chinook. Surveys indicated that the area above the barrier contained high quality spawning and rearing habitat. Correction of this culvert block constituted a portion of Project 84-5.

In Segment IV, dredge tailings were left perpendicular to the stream, and the channel meanders back and forth across the valley in a series of right angle bends. Pre-project surveys showed that pool area constituted about 51 percent of the habitat. They were highly embedded with fine sediment, and lacking in cover. Runs, most of which were relatively deep and slow, composed approximately 31 percent. Limiting factors in Segment IV included a lack of spawning gravels and insufficient instream cover.

Segment V, from the mouth to the beginning of the meanders in Segment IV, contains a mixture of straight and “meandered’ reaches. A new satellite rearing facility, constructed by the U.S. Army Corps of Engineers in 1989, is located in this segment. Characteristics and limiting factors here are similar to those in Segments I, II and Ill.

Segment VI is a narrow section of stream (locally known as Yhe Narrows”) in which dredging was limited by steep, constricting valley sidewalls. Tailings are only evident today in wider areas of the stream. Because dredging was minimal in this segment, large woody debris is present to create habitat diversity, and adequate riparian vegetation remains. Project activity focused on segments in greater need of rehabilitation than this one.

Section III: Contracts

Heavy equipment utilized during the course of the project was obtained through equipment rental contract. Many different kinds of machinery were used. They included: dozers (D-6 Cat, D-7 Cat, D-9 Cat), excavators (980 Case, 225 Cat, UH083 Hitachi, EX200LC Hitachi, 640HD International and 640ND International) and dumptrucks (Mack, Ford, International, Kenworth and Peterbilt). Forest Service fisheries biologists, hydrologists and biological technicians designed and directed installation of instream structures.

Outside technical expertise was obtained from the Albrook Hydraulics Laboratory, Department of Civil and Environmental Engineering, Washington State University (Orsborn et al., 1985); Water and Environmental Services of Boise, Idaho (Elliott, undated); Envirosphere of Bellevue, Washington (Martin et al., 1987); T. Bumstead of Pullman, Washington (Bumstead, 1987); and Clearwater BioStudies Inc., Sherwood, Oregon (Clearwater BioStudies, 1990).

Albrook Hydraulics Laboratory was contracted to design a hydraulically sound meandering channel to connect isolated dredge ponds in Segment II. The resulting report (Orsborn et al., 1985) examines the possibility of rerouting Crooked River through existing dredge ponds in two locations. However, the company's analysis revealed a risk that much of the stream would convert to subsurface flow. This concern led USFS personnel to adopt a second approach, which was identified as an alternative by Orsborn et al. (1985). This included constructing flood plains adjacent to the existing channel by removing unnatural accumulations of dredge tailings, and installing fish habitat improvement structures in the channel itself.

Envirosphere Company was contracted in 1986 to examine the unique fisheries habitat conditions created by the forced meanders in Segment IV. Objectives of this contract were to create a more natural channel with increased habitat diversity, to increase off-channel rearing areas, and to create a more stable stream channel. The Envirosphere Company final report (Martin et al., 1987) examines a number of alternatives including 1) no action; 2) creation of a flood plain by removal of tailings piles; 3) installation of instream structures: and 4) construction of side channels to connect off-channel dredge ponds.

Consultation between USFS, IDFG, Department of Environmental Quality and BPA in 1988 focused on these options for stream rehabilitation and fisheries habitat improvement in Segment IV. After considerable debate, is was decided that primary emphasis would be placed on riparian revegetation, creation of flood plains (by lowering tailings piles), and installation of cover within the existing channel pattern. This decision led to a contract with Water and Environmental Services, requesting detailed, site specific information to assist USFS biologists in implementing several chosen projects.

T. Bumstead was contracted in 1987 to determine the feasibility of connecting several dredge ponds to Crooked River by constructing a series of small side channels. Bumstead (1987) assessed three potential sites in Segments I and II. Two side channels were constructed in 1988, according to Bumstead's plans.

In 1990, a contract was let to Clearwater BioStudies, Inc. to assess the condition of the habitat in the project area, to define the distribution and abundance of salmonids, and to evaluate how the stream and its salmonid populations were responding to habitat enhancement efforts.

Cleatwater BioStudies (CBS) defined three study sections. "Section I' includes Project Segments III, IV and V, incorporating the over-meandered portion of Crooked River. 'Section II' corresponds generally with Project Segment VI, the Narrows. The upper Project Segments, I and II, were included in the CBS 'Section III: Also, CBS classified *enhanced* habitat units (i.e. pools, riffles, glides etc.) as either "created' or "improved,' depending on whether the enhancement created a new habitat type, or improved an existing one. CBS found that salmonid species reacted very differently to unenhanced, improved and created habitat units (Clearwater BioStudies, 1990).

Clearwater BioStudies estimated that the Crooked River Project Area contained over 67,500 salmonids at the time of their survey. Age 0+ trout were the most abundant (estimated at 45,133), followed by age 0+ chinook (9,893) whitefish (4,922), age 1 + steelhead (4,169), age 2+ steelhead (1,828), age 1 + chinook (800), residualized steelhead (502), catchable cutthroat (172), bull trout (81), trophy cutthroat (4) and brook trout (4). CBS estimates that juvenile chinook and steelhead parr populations are well below those that would be expected if existing habitat were fully seeded. Factors contributing to underseeding of habitat include 1) low escapements of chinook and steelhead spawners; 2) an inability of second-generation hatchery fish (i.e. 'natural spawners') to produce offspring that have high survival rates in the wild; and 3) a lack of hatchery supplementation of the relevant year classes of chinook and steelhead.

Section IV: Water Quality Concerns

Concerns were raised that the dredge ponds in the project area might contain harmful concentrations of heavy metals, and that project activities might mobilize toxic levels of these metals. Idaho Department of Health and Welfare, Division of Environmental Quality (DEQ), addressed these concerns by analyzing pond water and accumulated sediments in 1986 and 1987. DEQ established two sets of sample stations; one set lay within the project area, and one set in nearby tributaries. All but one of the stations in the project area lay within USFS Project Segment V. The remaining station was just upstream of the meanders in Segment Ill. DEQ examined several parameters including flow, temperature, oxygen, **pH,** specific conductance, common ions, trace metals, iron, zinc, copper, arsenic, lead, mercury and silver (Mann and Von Lindern, 1988).

The study concluded that project activity did not significantly affect the water quality in Crooked River. Sampling indicated that all selected metals, except for iron, were within Environmental Protection Agency (EPA) freshwater criteria for aquatic life. Iron concentrations in the sampled ponds exceeded EPA thresholds, and did cause iron levels in Crooked River to slightly exceed EPA criteria during the time of channel construction. However, iron concentrations quickly returned to background levels, and were not a cause for concern.

A concurrent EPA study characterized water quality parameters and in-situ toxicity in nine sample sites (Baldigo, 1986, in Mann and Von Lindern, 1988). This project was designed to provide information concerning the effects of trace metal concentrations in the dredge ponds on the physiology of juvenile summer steelhead trout and juvenile summer chinook salmon.

The EPA in-situ bioassay showed that even in ponds exceeding EPA thresholds of iron concentration, levels of the element did not produce acutely toxic effects on steelhead and chinook young-of-the-year (Ibid.).

Section V: Site Preparation and Barrier Removal

In 1984, a D-6 cat was used to construct access routes through the dredge tailings in at least three locations in Segments I and II. Because very little vegetation was established on the tailings prior to Project 84-5, vegetative disturbance was minimal. These access roads not only provided valuable access and places to store materials in close proximity to the creek, but also leveled areas in a way which will encourage natural revegetation.

Over 3,000 large boulders (.76 cubic meter) were hauled to the project site from an area near the mouth of Crooked River (Paradis, pers. comm.). These boulders were used in a variety of structures throughout the project period.

One of the first activities of the project was to replace the culvert at milepost 8.2 on the Crooked River Road (County Road 233). Original plans called for the installation of a pipe arch, but subsequent examination revealed that building a bridge would result in less damage to the channel and existing fisheries habitat. USFS engineers surveyed the area, designed the new bridge, and oversaw its construction in 1984 (Figure 6).

Figure 6. Idaho Dept. of Fish and Game releasing **adult steelhead into Crooked River from newly constructed bridge on County Road** 233.

Section VI: Instream Structures

Instream structures were constructed to provide cover, spawning habitat, winter rearing habitat and structural diversity. A total of 34 log weirs, 96 rock and boulder weirs, one Hewitt ramp, 70 deflectors, 240 boulders (singly and in complexes) and 238 pieces of large woody debris were installed in Crooked River during the course of Project 84-5 (Table 1). Most of the structures were installed in Segments I and II, where diversity in the habitat was lacking. in long, straight, homogeneous reaches of the river, structures were placed in groups, so that they would act upon each other (Figure 7). In late 1984, after 18 log weirs, 31 boulder weirs and 19 deflectors were installed in Segments I and II, a cursory survey revealed **a** continuing lack of cover. In 1985 crews returned to Segments I and II and used nearby conifers to add additional cover. In Segment IV, which already had a high pool:riffle ratio, emphasis was placed on adding cover to existing habitat types

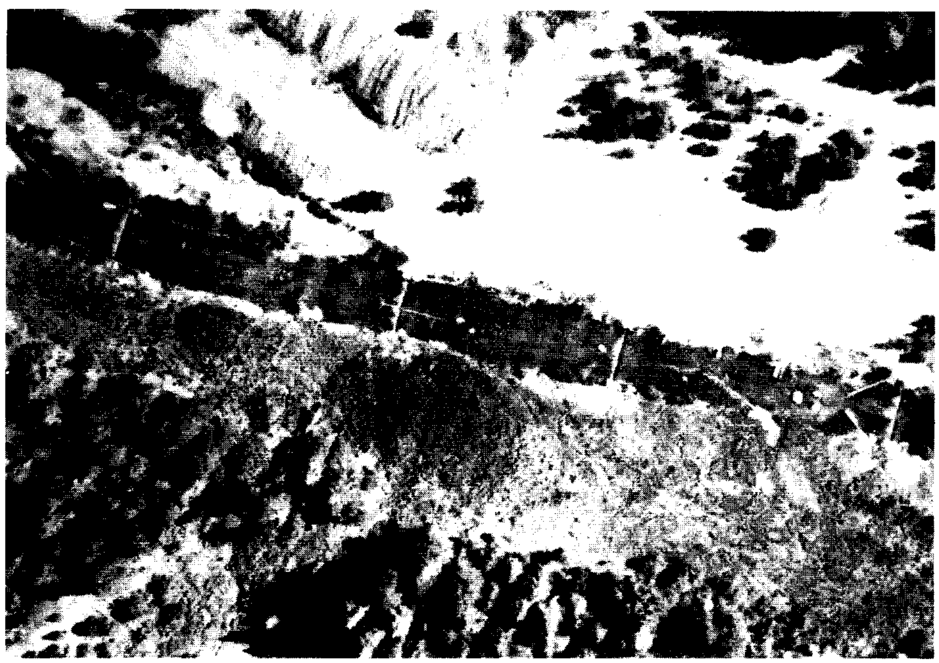


Figure 7. Detail of Project Segment II showing a series of structures, Crooked River, 1986.

Table 1. Crooked River instream structure accomplishments by year.

1984	Log weirs Rock and Boulder Weirs Deflectors Random Boulders Anchored Large Woody Debris Hewitt Ramp	18 31 19 59 23 1
1985	Log Weirs Rock and Boulder Wiers Deflectors Random Boulders Anchored Large Woody Debris	15 14 12 104 65
1986	Log Weirs Rock and Boulder Wiers Deflectors Random Boulders Anchored Large Woody Debris	1 19 0 23 23
1987	Log Weirs Rock and Boulder Weirs (check dams) Deflectors Random Boulders Anchored Large Woody Debris	0 17 0 5 5
1988	Log Weirs 'Rock and Boulder Weirs Deflectors Random Boulders Anchored Large Woody Debris	0 4 8 30 88
1989	Log Weirs Rock and Boulder Weirs Deflectors Random Boulders Anchored Large Woody Debris	0 11 31 19 56

Construction Methods: In general, installation of the structures required a hydraulic excavator. Individual elements of the structures were secured to bedrock or existing boulders with three-eighths to one-half inch galvanized cable (Figure 8). The cable was fastened using a gas-powered rock hammer drill manufactured by Hilti, and Hilti's C100 bonding material. Much of the work, like placing filter cloth and wire mesh, was completed by hand (Figure 9). Actual installation methods varied according to the conditions. For instance, in some cases, the fill behind a log weir was supported by 2 X 2 inch wire mesh and filter cloth, while in others fill material was placed behind the logs without additional support, Boulder weirs were constructed in both an upstream V and a downstream V configuration. Cover logs were sometlmes placed parallel to the flow and sometimes at an angle to it, sometimes cabled and sometimes buried in the bank. Some of the boulder structures were created with existing material, and some with granlte boulders brought from other locations,

Figure 8. Securing a rootmass with cable, Crooked River, 1986.

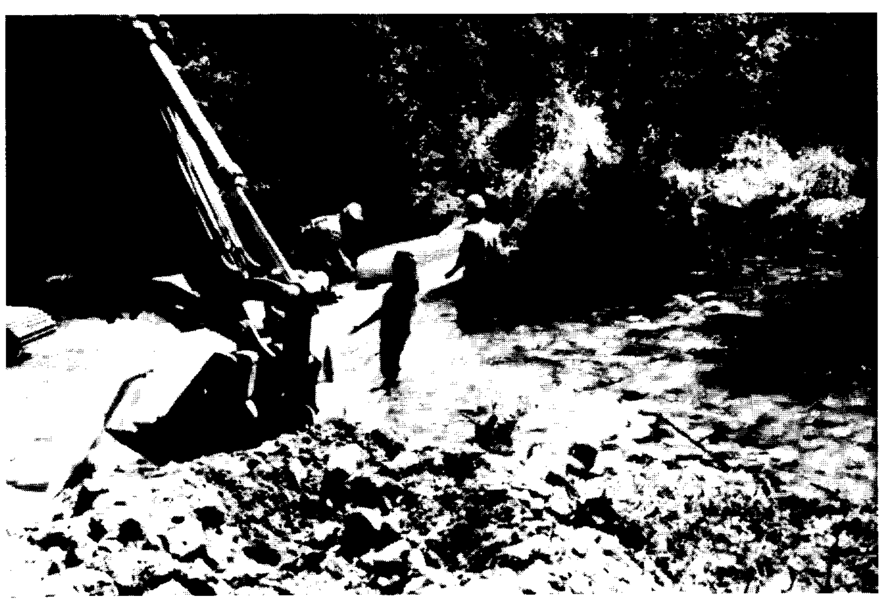


Figure 9. Constructing a log weir, Crooked River, 1985.

Structure Effect on the Habitat: According to CBS, 22.7 percent of the fisheries habitat in Section 1 (Project Segments III, IV and V) was directly affected by the USFS's instream structures. In contrast, 17.6 percent of the fish habitat in Section 3 (which includes Project Segments I and II) was affected by the structures. Overall (including the unenhanced Segment VI), 15.1 percent, or 34,164 square meters, of the fish habitat in the Project Area was directly affected by the instream habitat improvement structures themselves. These figures do not, of course, enumerate the positive effects of the bank reshaping and stabilization efforts. Furthermore, CBS noted that many of the smaller pools created by boulders, rootwads and other simple structures constituted "microhabitats" that were not separately identified in the "macro-habitat" approach of the survey, Therefore, enhanced areas too small to constitute separate habitat units, and nested within larger unenhanced units, are not included in these totals.

In Segments I and II, where emphasis was placed on creating pool habitat, CBS found that 66 percent of the existing pools were created by enhancement efforts (Figure 10). (CBS broke their three sections into 27 reaches. Reaches 20 through 24 roughly correspond to Project Segments I and II; these figures were derived from weighted averages of the values in Reaches 20 through 24.) One early USFS summary of the work in Segments I and II stated that instream structures had increased pool habitat from approximately 6 percent to 42 percent (Hair et al., undated). CBS biologists found that pool habitat in these segments totaled only 12 percent in 1990; this discrepancy is probably due to changes in survey methodology, and/or that some of the habitat units identified as pools by USFS personnel were identified as glides by CBS. According to CBS's figures, pools and glides now constitute 40 percent of the habitat.

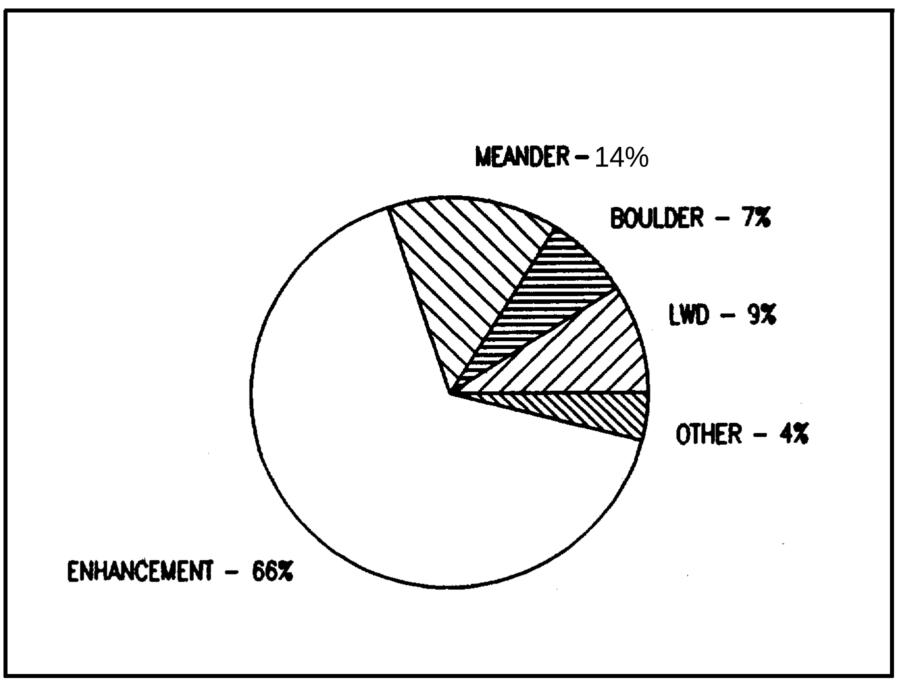


Figure 10. Pool Creator by percentage, Project Segments I and II, as determined by Clearwater Biostudies (1990).

Even in Project Segments III, IV and V, where emphasis was not placed on pool formation, 11 percent of the pools were created by enhancement techniques. Many more were enhanced by the addition of large, woody debris for cover.

Hair et al. (undated), state that instream cover increased from 1.5 to three percent due to structures placed in Segments I and II in 1984. In 1985, efforts were made to increase this figure even further. The CBS report shows that instream cover in Segments I and II was doubled again, and now rests at about six percent.

Structure Utilization: IDFG personnel noted adult chinook use of newly sorted spawning gravels and the Hewitt ramp pool as early as 1984 (Petrosky and Holubetz, 1985). It was also noted that in Project Segment I, adult steelhead spawned in areas containing instream structures more than four times as much as in unenhanced sections (Petrosky and Holubetz, 1986). USFS personnel observed adult chinook and steelhead using created pools for cover, and pool tailouts for spawning, throughout the project period. Eight chinook redds, all in gravels associated with structures, were identified in the project area in 1989.

Clearwater BioStudies (1985) identified different salmonid responses to ‘improved habitat units" (an existing pool into which some debris was placed, for instance), than in "created habitats" (which, for example, might consist of a pool-forming weir in an area that was previously riffle). Mean densities of age 0+ trout and age ½+ steelhead were higher in created units than in unenhanced ones, but they were lower in improved units than in unenhanced ones. Age 0+ chinook densities were also lower in the improved habitat units than in the unenhanced ones,

This preference of unenhanced habitat units to improved ones may be explained by the fact that areas in which USFS chose not to place structures were generally better habitat than areas in which they improved or created habitat. Therefore, it does not indicate that the improved habitat units aren't preferable to the habitat that existed prior to improvement (Ibid.).

Unenhanced *riffle* habitat units provide an acceptable control with which to evaluate the effectiveness of created structures, because the unenhanced riffle habitats are more comparable to the habitat that existed prior to the installation of the structure. Comparison of densities in unenhanced riffle units to densities in created units shows a strong preference in juvenile salmonids for the created units. It is possible to conclude then, that the USFS enhancement efforts created new habitat units that juvenile steelhead and spring chinook prefer over the habitat from which the new units were created (Ibid.)

In 1986, USFS compared densities of 0+ chinook in one section of improved channel and one section of unimproved channel, and found significantly higher levels of 0+ chinook in the improved section of the river. That these results contradict those of Clearwater BioStudies may be due to one or both of two things. First, the USFS study section (the ‘improved" section) probably contained a mix of what CBS would have defined as ‘improved" and "created' habitat units. Second, there may have been a different proportion of hatchery vs wild chinook fry in the years the studies were conducted. A higher proportion of hatchery fry in 1986 might explain increased use of the additional slackwater in improved areas, as hatchery stock are known to prefer different habitats than wild stock (Thompson, 1990). A lower number of hatchery fry in 1990, when CBS conducted its research, may have resulted in different habitat selection by the higher proportion of wild fish.

Both CBS biologists and USFS biologists noted that fish are abundant where enhancement structures provide lower velocities and cover in relatively faster flowing areas of the stream, but that fish are not as abundant near structures that are positioned in areas of negligible current velocity. Structures in low velocity areas are not valuable to the fish as feeding stations, and, naturally, do not provide advantageous holding areas. In addition, water velocity in low gradient slow sections of stream was not adequate to scour pools, or to prevent sediment buildup in the vicinity of the structure.

Thompson (1990) assessed steelhead summer use of the structures in Crooked River during 1988 and 1989. She found that both hatchery and wild steelhead of larger size were found in highest densities in pools. This corresponds to work she cites by Chapman (1966), Chapman and Bjornn (1968), and Everest and Chapman (1972), which finds that smaller juvenile salmonids are known to prefer swifter, shallower habitats, Thompson concluded that larger juvenile steelhead are the ones primarily benefiting from the summer rearing provided by the artificial pools, but that smaller juvenile salmonids may indirectly benefii due to a reduction of intraspecific competition in other habitats during the summer months.

Structure Maintenance Requirements: In a project of this scale, it is not unexpected that a few structures should fail or require some reconstruction. In Crooked River, where some 660 instream structures, boulders or pieces of large woody debris were installed, maintenance requirements have been remarkably limited. Most of the problems encountered subsequent to structure installation were the result of poor structure placement. Structures placed in low velocity areas of meander bends sometimes failed to provide the desired increase in habitat quality. In several cases, longer trunks on the rootwads used in cover structures would have allowed the rootwad itself to extend farther into the thalwag, where it would have provided greater benefit. A few weir structures that were placed in areas where banks were low have exhibited erosion at the edges. Cover logs and trees placed at an angle to the flow created far better habitat than those placed parallel to the flow. Logs placed parallel to the flow caused sediment deposition and braiding. In this stream, the habitat diversity created by the braiding was not a desired effect.

Table 2. Crooked River stream structure maintenance requirements by year.

1986	Boulder Weirs Hewitt Ramp	2 1'
1989	Boulder Weir Rock Deflector	1 1
1990	Boulder Weirs Boulder Clusters Boulder Deflectors Anchored Debris	5 1 4 9

Until 1987, most of the rock weirs placed in the channel were constructed in a downstream V configuration. Water forced off the sides of the V began to erode the banks in some of these structures. Crews in 1989 and 1990 reversed six of these structures to an upstream V configuration. The upstream Vs will create pool habitat by concentrating water to the center of the stream, rather than forcing it to the banks (Figure 11).

In several cases, structures created pools as planned, but the pools are shallow and lacking in cover, and therefore of negligible benefit to fish. Although state-of-the-art technology at the time, log weirs that increase stream width:depth ratios, and create large, shallow pools, are now known to be of questionable value. In general, more emphasis should have been placed on pool quality than pool quantity, and more attention should have been paid to reducing width:depth ratios.

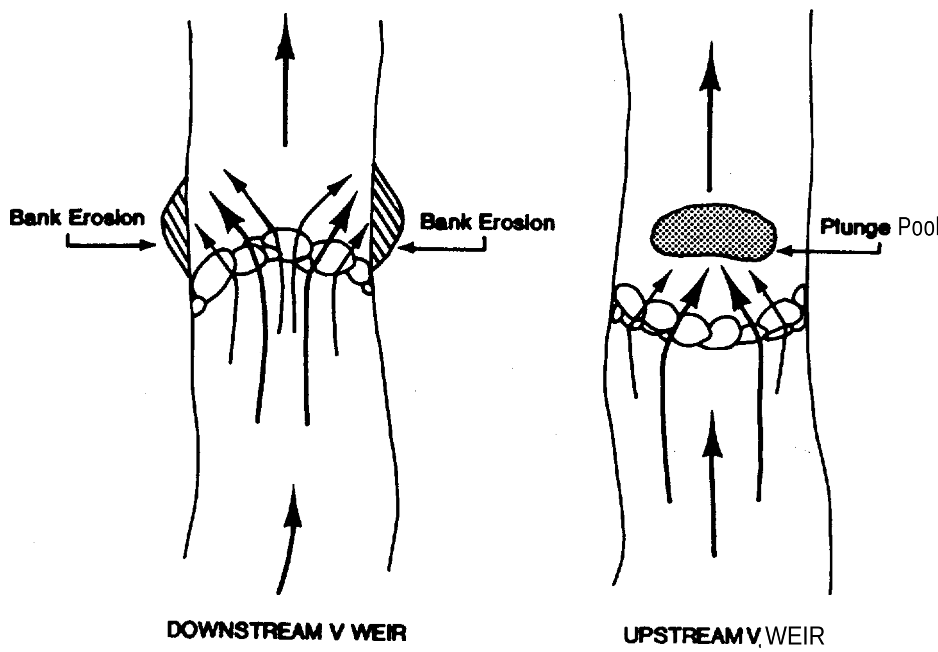


Figure 11. Comparison of hydraulic action on a downstream and an upstream boulder weir, showing erosion potential (downstream v) and pool formation (upstream V).

Section VII: Side Channels and Pond "Connection"

USFS personnel observed that in several ponds in Segment IV, smolts were actually trapped in dredge ponds when their subsurface entrance routes dried in mid-summer. Over 2,600 meters of side channel were constructed adjacent to Crooked River, mostly to ensure year-round access to existing dredge ponds. The side channels and the ponds increase the quantity of juvenile rearing and wintering habitat by some 15,000 square meters.

Construction Methods: A hydraulic excavator was used to dig the channels, while finishing work, like placing rip rap, planting and installing small weirs, was conducted by hand (Figure 12). Whether or not a pond was connected to the main channel at both ends, or only at the lower end, depended upon the individual characteristics of the pond. In some, water continues to enter through subsurface routes, but now drains through constructed outlet channels. In others, half weirs or partial rock berms were constructed in Crooked River in such a way as to encourage flow into the ponds. Culverts were installed at the head of a number of pond intake channels to provide a constant flow while preventing Crooked River from rechannelizing through the newly connected ponds. In several cases, especially those where channels were excavated perpendicular to the slope, water tended to seek previously established subsurface routes instead of following the new channel. Likewise, water in several of the ponds continued to drain through subsurface routes rather than follow the connecting channels.

Figure 12. Pond connection. Project Segment I, Crooked River. 1987.

Small log weirs were constructed in channels between ponds to maintain an even grade from one pond's elevation to the next, thereby preventing downcutting which would drain the ponds. The pools formed by these weirs provided additional habitat for the fry utilizing these off-channel areas.

In one series of five ponds that were connected in 1987, the **75-meter** outlet channel from the downstream pond dried completely during summer months. In this case, crews excavated about 30 cm of substrate from the bottom of the pond and the channel, which were then lined with filter cloth. The excavated substrate was used to bury the cloth. The lining of the pond and channel, however, did not alleviate the problem, and flows still disappear into the cobble in mid-summer. In this case, the series of connected ponds fails to provide summer rearing habitat, and no method to prevent the subsurface flow was identified.

Pond and Channel Utilization: Very few of the ponds connected by side channels during this project previously provided winter habitat. Flow in most was insufficient to provide appropriate depth and aeration. Now, however, all of these ponds provide winter habitat for juvenile salmonids. In addition, several of the ponds also provide summer habitat, although water levels in others recede, and the water becomes too warm and stagnant for **salmonid** utilization,

USFS crews in 1985 observed two juvenile chinook in one of the ponds in Segment II shortly before it was connected to the stream. **Within** a week after the pond was connected, more than 150 chinook fry and 50 steelhead fry were observed in it. In 1986, a year after it was constructed, more **than 100 steelhead smolts,** which had been stocked in the river, were observed in that same pond (Hair **et al.,** undated). **Early in the** spring of 1989, a smolt trap was established at a pond outlet in Segment IV. **The trap was monitored for** eight days, until an otter or other small mammal began systematically eating the fish. During that **time,** 48 chinook and ten steelhead smolts passed through the trap, showing utilization of the pond as winter rearing habitat.

USFS monitoring in 1986 comparing salmonld densities in a section of main **channel with those in a side** channel (parallel to that section of main channel) revealed a significantly higher use of the side channel by 0+ steelhead and chinook, 1+ wild steelhead, and 1+ and **2+** hatchery steelhead (Table 3). Idaho Department of Fish and Game noted that chinook parr densities in the connected ponds were consistently among the highest they observed in the project area (Kiefer and Forster, 1991). **IDFG** concluded that the off-channel ponds can support higher chinook parr densities than streams, and that connection of off-channel ponds should result in increased chinook rearing potential.

Clearwater **BioStudies** compared utilization of constructed side channels with that of previously existing, natural side channels. They found that while densities of age 0 chinook were significantly higher in created sidechannels than in natural sidechannels, densities of age 0 trout and age **½+** steelhead were both significantly lower. CBS suggests that the age 0 trout and age **½+** steelhead preference for unenhanced sidechannels is possibly due to the greater proximity of the natural channels to the main channel.

Table 3: Comparison of salmonid densities in parallel sections of main channel and created side channel (USFS data).

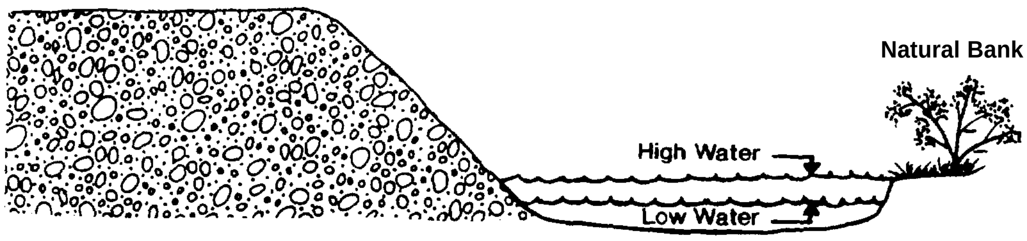
	DENSITY/m*	
	Main Channel	**Created Side Channel**
0+ steelhead	.155	.43
0+ chinook (hatchery)	.127	**2.03**
0+ chinook (wild)	.035	.26
1+ steelhead (wild)	.07	.24
2+ steelhead (hatchery)	.007	.03

Figure 13. A series of ponds connected with side channels in 1986. and a side channel created in 1986 (left edge of picture). Project Segment II, Crooked River.

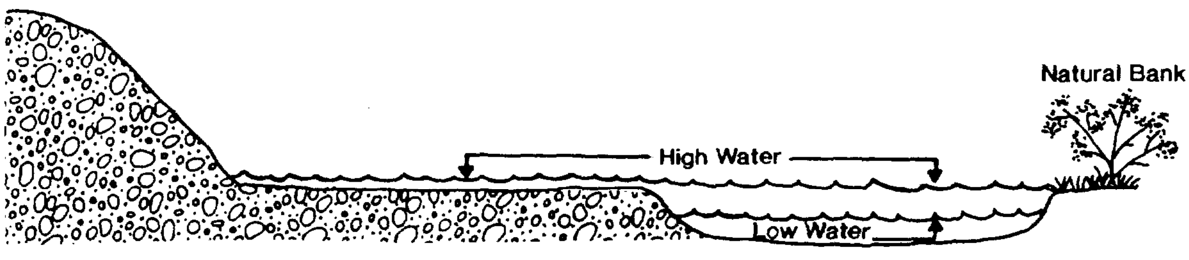
Section VIII: Flood Plain Development

In several places where dredge tailings had unnaturally constrained the channel, a hydraulic excavator and dumptruck, or in other cases, a D-6 cat, were used to remove enough of the tailings material to create a flood plain. Between 1985 and 1989, over 9,000 square meters of flood plain were constructed, mostly in Project Segments II and III. The flood plains were designed to allow yearly overflow at times of high runoff (Figure 14). In most cases, erosion control matting was placed on the flood plain to help collect silt from the overflow. In some cases, fine organic material and silt were excavated from nearby ponds and deposited on the flood plains to serve as growing medium, Large cobble and boulders uncovered during flood plain construction were often returned to Crooked River, creating interstitial space to increase habitat diversity and winter habitat. The new flood plains were seeded, fertilized and mulched (Figures 15 and 16).

In some areas of Segment IV, concern developed that flood events might cut too easily through the shallow flood plains, and lead to drastic rechannelization. Water and Environmental Services addressed this concern in their report, supplying blueprints of berms engineered to contain a 50-year flood event estimated to peak at 3,300 cfs (Elliot, undated). The berms were designed to balance channel integrity and aesthetics, and leave some room for yearly overflow to encourage natural regeneration of riparian vegetation Twelve of these berms were constructed in 1987 and 1988 to protect constructed flood plains.



Before removal of tailings (existing condition).



After removal of tailings.

Figure 14. Cross-section of flood plain constructed by removal of dredge tailings adjacent to the stream channel.

Figure 15. Newly created flood plain in Project Segment II, 1986.

Figure 16. Same flood plain, one year after seeding.

Table 4. Flood plain development, Crooked River.

1985	1,964 m^2 flood plain created
1986	1,756 m^2 flood plain created
1987	810 m^2 flood plain created (3,442 m^3 tailings excavated and removed)
1988	4,700 m^2 flood plain created (20,285 m^3 tailings excavated and removed) 3,825 m^3 fines excavated from ponds and placed on flood plain for growing medium 594 m additional berm constructed
1989	1,200 m^2 flood plain maintained

During high flows in years following flood plain development, it became evident that much of the created flood plain in Segment II was not quite low enough to allow consistent overtopping at high flows, In subsequent years, additional leveling helped lower these areas to a more suitable height.

Erosion control matting placed on the flood plains worked very well to capture and hold sediment as the water receded. High flows and accompanying debris, however, put a great deal of pressure on the matting, and the greatest success in keeping the matting in place occurred where cobble was placed on the matting on a minimum of two-meter centers (Figure 17). (The large staples supplied by the company to hold the matting in place were found to be ineffective in cobble.) Project biologists recommend placing more erosion control matting in areas where flood plain vegetation would benefit from increased silt buildup. Created flood plains in Segment II, which are not building a soil and vegetational base as quickly as hoped, might respond well to this treatment. In addition, anchored woody debris or small structures on the flood plain might help to trap and hold sediment as the flood waters recede.

Figure 17. Example of erosion control matting held at high water by cobble on two-meter centers.

Section IX: Bank Stabilization and Riparian Area Revegetation

Bank Stabilization: In some areas, where sharp bends had **forced** water against loosely structured dredge tailings, banks were unstable and eroding. Bank stabilization efforts included redesigning and reshaping the bank profile, installation of rip rap, construction of instream structures designed to direct flow away from erosive sites, and revegetation. A hydraulic excavator and a D-7 cat were used in 1984 and 1985 to complete almost 7,000 square meters of bank stabilization. Disturbed surfaces were seeded, fertilized, mulched, and planted by hand.

Shrubs: During the seven-year project period, some 28,000 hardwood shrubs were planted in Crooked River riparian areas. Shrub species included alder and local willow varieties, cottonwood, snowberry (Symphoricarpos spp.), red osier dogwood, honey locust (Gleditsia triacanthos intermis), Pacific golden willow, Arctic blue willow (Salix spp.), and a few Siberian pea (Caragana arborescens) and Russian olive (Elaeagnus angustfolia). In addition, 2,000 conifer seedlings, including Engelmann spruce, Douglas-fir, ponderosa pine and lodgepole pine, were planted in 1989. The stock was either ordered from several different nurseries, containerized or bare root, or cut from local vegetation.

Table 5. Crooked River riparian planting projects by year.

1984	Containerized Shrubs	350
	Willow Cuttings	1000
1985	Transplanted Brush Clumps	12 willow 4 snowberry 17 alder 1 serviceberry
	Nursery Stock	50 cottonwood 125 red osier dogwood 300 hybrid willow 25 Siberian pea 25 golden willow 25 Arctic blue willow 500 alder
	Cuttings	2,150 red osier dogwood 2,150 willow
1986	Transplanted Brush Clumps	7 willow 57 alder 14 hawthorne
	Shrubs and Trees	215 cottonwood 153 willow
1987	Transplanted Brush Clumps	15 alder
	Nursery Stock	250 alder 250 red osier dogwood
	Cuttings	330 cottonwood
1988	Shrubs and Trees	10,000 mountain alder, red osier dogwood, snowberry
1989	Shrubs and Trees	200 willow 2,000 conifer

Thousands of the shrubs were cuttings taken from native willow and cottonwood already established near the river. Cuttings of both species were made in early spring, before budding. Willow cuttings were stored in coolers until milder spring weather, when their cut ends were dipped in Rootone just prior to planting. Cottonwood ends were immediately dipped in Rootone, and then placed in potting soil. By fall the cottonwood cuttings had developed root systems adequate for planting.

In 1985, four test plots were established to help determine shrub success. The plots consisted of a grid of six species of shrubs on 2-foot centers (roughly 36 shrubs per plot). Shrubs used in these experimental plots included Pacific golden willow, red osier dogwood, Populus sp., honeysuckle, honey locust, Russian olive and Siberian pea. Some of the stock was rooted (nursery), while the remainder consisted of cuttings.

By the fail of 1985, 80 percent of the shrubs planted in the test plots that spring had succumbed to drought (Paradis, pers. comm.). More general observations early in the project period substantiated that shrub survival rates were indeed disappointing. None of the hawthorne or the Siberian pea survived. Containerized stock from nurseries did not appear to be appropriately climatized, and often did not survive the transfer from warm nurseries to cold spring nights. In general, locally cut or **bareroot** stock was more successful than containerized stock, and willow **and alder survived in greater numbers than** the other species.

Clearly, one of the greatest challenges in rehabilitating **a** dredge-mined system is the lack of growing medium for new vegetation. Not surprisingly, shrubs grew best where shade and topsoil were present. Results of the early planting attempts proved that it is not cost-effective to plant on the dredge tailings themselves. After the first year of the project, more emphasis was placed on creating natural bank conditions. For example, flood plains were created to encourage soil formation and revegetation. Where top layers of cobble were removed, finer material was often exposed. And even where the flood plain surface remained mostly cobble, greater proximity to the water table afforded seedlings better growing conditions.

In 1988, 3,825 cubic meters of silt were excavated from ponds and placed on newly created flood plains in Segments III and IV. The silt remained on the cobble surface satisfactorily, and grass growth was clearly more vigorous in these areas. Shrubs are expected to benefit both from nutrients in the silt itself, as well as from the protective and soil building characteristics of the grass. Project biologists recommend that this practice be continued, possibly by using a suction dredge to transfer silt from ponds to cobble surfaces. It would also be beneficial to spread topsoil in areas where it is proving particularly difficult to establish vegetation,

Greater natural coniferous revegetation in Crooked River's riparian zones is occurring in areas where the dredge tailings have been leveled. Indirect benefits are expected from access roads, stockpile sites and other areas that have been flattened, even where the substrate itself is substantially unchanged.

Clump Planting (Shrubs): Approximately 130 "clumps" of shrubs were also planted in rehabilitated areas. An excavator was used to dig holes in the dredge tailings, and transplant whole "clumps" of shrubbery into them (Figure 18).

Figure 18. Clump planting in progress.

Clump planting of native alder and willow was fairly successful. Survival would have been higher had the planting occurred in early spring or late fail, rather than during the hot, dry summer period. It is felt that planting of shrub complexes has a great deal of potential, and project biologists recommend continuing the practice, as long as the plantings are made at an appropriate time of year.

Seeding: Disturbed sites (stabilized banks, flood plains and other bare soil) were seeded with a variety of grass seed including annual rye (Lolium multiflorum), white clover (Trifolium repens), reed canarygrass (Phalaris arundinacea), orchardgrass (Dactylis glomerata) and hard fescue (Festuca ovina var. duriuscula). Seed was generally applied heavily, at levels approximating 16 lbs/hectare (40 lbs/acre). In most cases, fertilizer was applied as well, at about 160 lbs/hectare (400 lbs/acre). At least 400 bales of straw and 20 rolls of erosion control matting were applied as mulch in unstable areas.

Because of its quick-growing properties and heavy rootmass, and because thick mats of it can even provide instream cover, more reed canarygrass was planted than any other grass species. Yet while the reed canarygrass has proliferated, and is undoubtedly holding soil in place as hoped, it appears to be inhibiting the recolonization of native grasses and shrubs. Shrubs are particularly desired because they can provide stability from deep root systems, and overhanging bank cover, in a way that grass can't. USFS biologists now feel that greater emphasis should have been placed on native grasses that would not have inhibited shrub growth.

Section X: The Project Implementation Schedule

1984 Created several access routes through the tailings piles in Segments I and II.
Brought 3,000 boulders to site.
Installed several series of structures in Segments I and II.

1985 Anchored additional cover in Segments I and II.
Installed additional structures in Segments I and II.
Bank stabilization in Segment I.
First pond connection in Segments I and II.
First flood plain construction in Segment II.
Albrook Hydraulics Laboratory contract completed.

1986 Continued to install structures in Segments I and II.
Continued work on flood plains begun in 1985 in Segment II.
Continued to connect ponds by constructing inlet and outlet channels.
Created a side channel in Segment II.
Water quality studies.

1987 Continued pond connection in Segment I.
Moved emphasis away from structure installation in Segments I and II to pond and side channel connection in Segment IV.
Initiated flood plain development in Segment IV.
Water quality studies.
T. Bumstead contract completed.
Envirosphere contract completed.

1988 Continued pond connection in Segment IV.
Maintained emphasis on flood plain construction in Segment IV.
Installed cover in Segment IV pools.
Water and Environmental Services contract completed.

1989 Maintenance on ponds in Segment I.
Completed flood plains in Segment IV.

1990 Structure maintenance.
Cleat-water BioStudies contract completed.

Section. XI: Summary and Conclusion

Project 84-5 activity in Crooked River was large-scale and diverse. Some 660 instream structures, boulders or pieces of large woody debris were installed in the channel to increase diversity and provide quality holding and wintering habitat. These structures affected 17.6 percent of the fish habitat in the project area, and created 66 percent of all the pools in Project Segments I and II. In addition, over 2,600 meters of side channel were constructed, both to supply additional rearing habitat and to connect dredge ponds to the main river. The side channels and the ponds increase the quantity of juvenile rearing and wintering habitat by some 15,000 square meters. Approximately 9,230 square meters of flood plain were created adjacent to Crooked River by removing dredge tailings that had unnaturally constricted the flow. To help re-establish deep-rooted shrubby vegetation and overhanging bank cover, some 28,000 hardwood shrubs and 2,000 conifer trees were planted in Crooked River's riparian areas.

In 1988, the Western Division of the American Fisheries Society awarded the Nez Perce National Forest for excellence in riparian management at Crooked River, Recently, the Project was featured on a tour Of foresters from foreign countries. Several lessons were learned during the course of 84-5 project work that have particular significance to other projects of this nature.

1. Instream structures are successful only where objectives are well defined, and where hydrological patterns thoroughly analyzed, Some kinds of structures, like the classic log weir, can actually widen the channel, which in most cases is an undesirable effect. The large, shallow ponds with little cover that form above the log structures are marginal fish habitat, and the plunge pools created below the structures can be created with other kinds of structures that do not increase width:depth ratios. In Crooked River, several kinds of structures were installed that both supplied immediate fish habitat and contributed to the long term stability of the channel. These structures (which include upstream rock V weirs, as well as deflectors and pinch weirs) force water to the center of the channel where it will scour pools in a natural meander.

2. Planting shrubs directly on tailings piles is not recommended. Success is marginal, and the practice not cost effective. A suitable topography and growing medium should be established prior to the planting of shrubs.

3. The removal or leveling of dredge piles to create natural banks and flood plains has been extremely successful. The result is aesthetically appealing, and encourages vegetative recolonization. Both shrub and conifer growth are markedly improved. A more natural topographical configuration will allow riparian communities to restabilize, and a healthy riparian area will assist the channel itself in restoring its dynamic equilibrium.

4. Erosion control matting on the newly constructed flood plains was quite effective in collecting silts from runoff, and helping to establish a growing medium for natural forb and shrub growth. USFS biologists strongly recommend the use of erosion control matting in situations similar to this one.

5. Rehabilitating a system so drastically affected by dredge mining is an exceedingly difficult, costly and lengthy process. Planning and design are critical. In future efforts, particularly those conducted in meandering, meadow reaches (C channel types [Rosgen 1985]), emphasis should be given to restoring natural channel pattern with respect to width:depth and pool:riffle ratios. Project work would benefit from more rigorous definition of appropriate locations and elevations for bankfull stage, the flood plain, and valley terraces above the flood plain.

Section I: Introduction

Surveys conducted between 1974 and 1991 by the Idaho Department of Fish and Game evidence the importance of Red River as an anadromous fishery. These surveys indicate that Red River has the highest number of naturally reproducing chinook in the South Fork Clearwater system, and in eight of these years, IDFG identified more redds in Red River than in any other tributary in the Clearwater River Basin (Idaho Department of Fish and Game, unpublished).

In 1962, IDFG installed two incubation channels at the Red River Ranger Station: both are simple gravel bed diversion ditches, with weirs to control water flow from the river. In various years from 1963 to 1988, these channels were planted with between 180,000 and 1 .1 million steelhead eggs. Red River is also the site of a Cleatwater Fish Hatchery satellite facility, which was constructed in 1977 as part of the Lower Snake River Compensation Plan. At the satellite, gametes are taken from two-thirds of the chinook adults migrating to upper Red River. An acclimation pond at the facility annually holds between 40,000 and 350,000 chinook fry for approximately one month before they are released into the river.

Large volumes of stored sand-sized sediment in several undisturbed tributary watersheds indicates that cobble embeddedness in Red River may be naturally higher than that in other local streams. Nevertheless, it is clear that land management activity has contributed to increased sediment production in the river. The mainstem Red River has been more greatly affected by management activities than the South Fork Red River, and studies show that it produced 2.7 times the unit area average sediment yield as the South Fork between 1986 and 1990 (Gerhardt, 1991). Sedimentation has reduced interstitial volume available to overwintering fishes and incubating eggs, and is a significant habitat limitation in Red River.

Like Crooked River, parts of Red River were dredge mined in the 1940s and 1950s, although the channel was not left in the exaggerated meander pattern that so uniquely characterizes portions of Crooked River. Several miles of Red River were straightened by the mining, and in some reaches the coarse material removed from the channel remains heaped in tailings piles along its banks. Dredging generally resulted in increased sedimentation, and in reduced bank stability, habitat diversity, pool cover, overhanging bank cover and shrubby riparian vegetation. Accelerated bank erosion above and below the dredged areas indicates that channel straightening indirectly affected most of the other meandering meadow areas of the river. It is likely that lowered base levels (lowered streambed elevations) in the mined reaches caused channel degradation (bed cutting) upstream, and that sedimentation and increased channel sediment storage caused accelerated meander shift downstream. The resulting bank erosion was probably exacerbated by the absence of deep-rooted riparian vegetation which resulted from grazing and deliberate shrub eradication on the Red River meadows.

The privately owned meadows adjacent to Red River have been grazed since about 1910 (Nez Perce National Forest, 1967) and riparian Forest lands above the Ranger Station were included in the Red River grazing allotment from 1922 to 1983. In Upper Red River, where dredge mining did not occur, grazing appears to have caused channel widening, bank sloughing and loss of riparian vegetation.

Project 84-5 was initiated in Red River to address habitat limitations caused by the increased sedimentation, the lack of overhanging bank and riparian cover, and the lack of habitat diversity. Furthermore, project activity, by definition, supported USFWS and IDFG efforts by increasing the quality of juvenile and adult rearing and holding habitat. The project objectives outlined in the original BPA/USFS agreement were 1) increasing rearing habitat for fish through installation of stream structures; 2) reversing the degradation of streambank cover by re-establishing hardwood and conifer vegetation; 3) protecting the riparian zone from continued grazing impacts on USDA Forest Service and private land through streamside fencing; and 4) stabilizing areas disturbed by previous dredge mining.

In addition, that agreement identified a secondary objective, which was to provide examples of riparian area management techniques compatible with grazing of private pastures which may be utilized by other landowners in the future.

Project 84-5 activity in Red River was complicated by the fact that much of the degraded habitat is on privately owned land. Bank erosion on private lands was identified as a significant sediment source, but corrective action was often forestalled by legal problems associated with acquiring riparian easements, and difficulties in providing for long-term maintenance of structures and fencing. While several informal agreements with private landowners were reached that allowed project activity on private ground, these agreements do not specifically provide for future maintenance needs, Public-land reaches received a disproportionate amount of corrective activity, because permission to work on private ground was frequently delayed or never received.

During the course of Project 84-5 activity in the mainstem of Red River, USFS provided matching funds for rehabilitation efforts in the South Fork Red River and Red River tributaries. Between 1985 and 1989, USFS cost-share monies were used to install instream structures in South Fork Red River, as well as to construct side channels and to revegetate harvested areas of its floodplain. Between 1983 and 1989, six sediment traps were constructed (with cost-share monies) in Red River and its tributaries in an effort to decrease the amount of sand-sized sediment reaching anadromous fish rearing and spawning areas. Ongoing USFS efforts to reduce erosion due to road construction, road reconstruction and timber harvesting activities are expected to assist in the recovery of the Red River system.

This chapter describes the kinds and extent of BPA-funded rehabilitation activity in Red River. It includes a general overview of instream structure installation, bank restabilization efforts, side channel reconstruction, and riparian area revegetation.

Section II: Project Area

Red River drains a basin approximately 41,340 hectares (103,400 acres) in size (Figure 19). Elevations within this basin range from 1,220 to 2,130 meters (4,000 to 7,000 feet). Slopes are moderate (predominately 25 percent to 40 percent), although slopes over 40 percent occur along major stream courses. There are approximately 1,450 kilometers of identifiable stream channels from first to seventh order (Nez Perce National Forest, 1984).

The annual precipitation varies with elevation, ranging from 63 cm (25 inches) below 1,500 meters (5,000 feet) to 114 cm (45 inches) above 1,830 meters (6,000 feet). Snow depths above 1,830 meters may exceed two meters in winter; in the spring, snowmelt constitutes 83 percent of the total runoff volume. Data from recording gages in the mainstem and South Fork Red Rivers show that about 30 to 35 percent of the annual water yield is generated in May, while the remainder runs off in 2.5 to 5 percent monthly increments. 'Chinook" conditions produce winter flooding in December and January at an average of once every eight to ten years (Ibid.).

Soils: Red River is located in an area of Belt Supergroup rocks, principally biotite schist and augen gneiss, with outcrops of Idaho Batholith quartz monzonite. The soils formed on these parent materials tend to be sandy, and like soils of the northern Idaho batholith (nearby), produce only meager levels of nutrients to area waters. Because of this, streams in the area may have only a moderate natural carrying capacity for fish, although the methodology for correlating fish production capabilities with stream nutrient levels has not been established for soils of this type. The re-establishment of riparian vegetation, identified as a Project 84-5 goal, will increase nutrient levels in the stream by providing detritus and food web support.

Vegetation: The vegetation along the stream course is varied; meadow openings are intermittent among hardwood and conifer cover. Hardwood species are dominated by alder, willow, dogwood and Rocky Mountain maple. Conditions occurring along Red River and its tributaries favor Engelmann spruce, grand fir, Douglas-fir, lodgepole pine, subalpine fir, ponderosa pine and larch. Much of the lodgepole is of a condition and age which makes it susceptible to mountain pine beetle infestation. Lodgepole was harvested in several riparian areas of main and South Fork Red River and its tributaries in the 1980s.

Wildlife: The meadows adjacent to Red River are highly used elk calving areas. The river is also home to beaver, whose dam-building propensities continue to affect its channel in various ways and places. River otter, moose, elk, white-tailed deer, mule deer and black bear are frequently observed. The meadows once provided high quality waterfowl habitat, and while dredge mining and other land uses have undoubtedly decreased the quantity and quality of this habitat, the area continues to serve as a spring migration stopover for many species of waterfowl and shorebirds: tundra swans, horned grebes, great blue heron, American bittern, northern pintails, green-winged teal, blue-winged teal, American widgeon, buffleheads, harlequin ducks, ruddy ducks, hooded merganser, common merganser, killdeer, common snipe, spotted sandpiper, greater yellowlegs, and Wilson's phalarope. Several species nest in the meadows; they include Canada geese, mallards, cinnamon teal, killdeer, common snipe, spotted sandpipers, belted kingfishers and dippers. Goose nesting platforms were constructed by IDFG in 1989, and approximately 60 pairs of Canadian geese were relocated to the meadows in 1989 and 1990. Project activity benefits all of these species by encouraging riparian vegetation, and creating additional wetlands through side channel and pond construction.

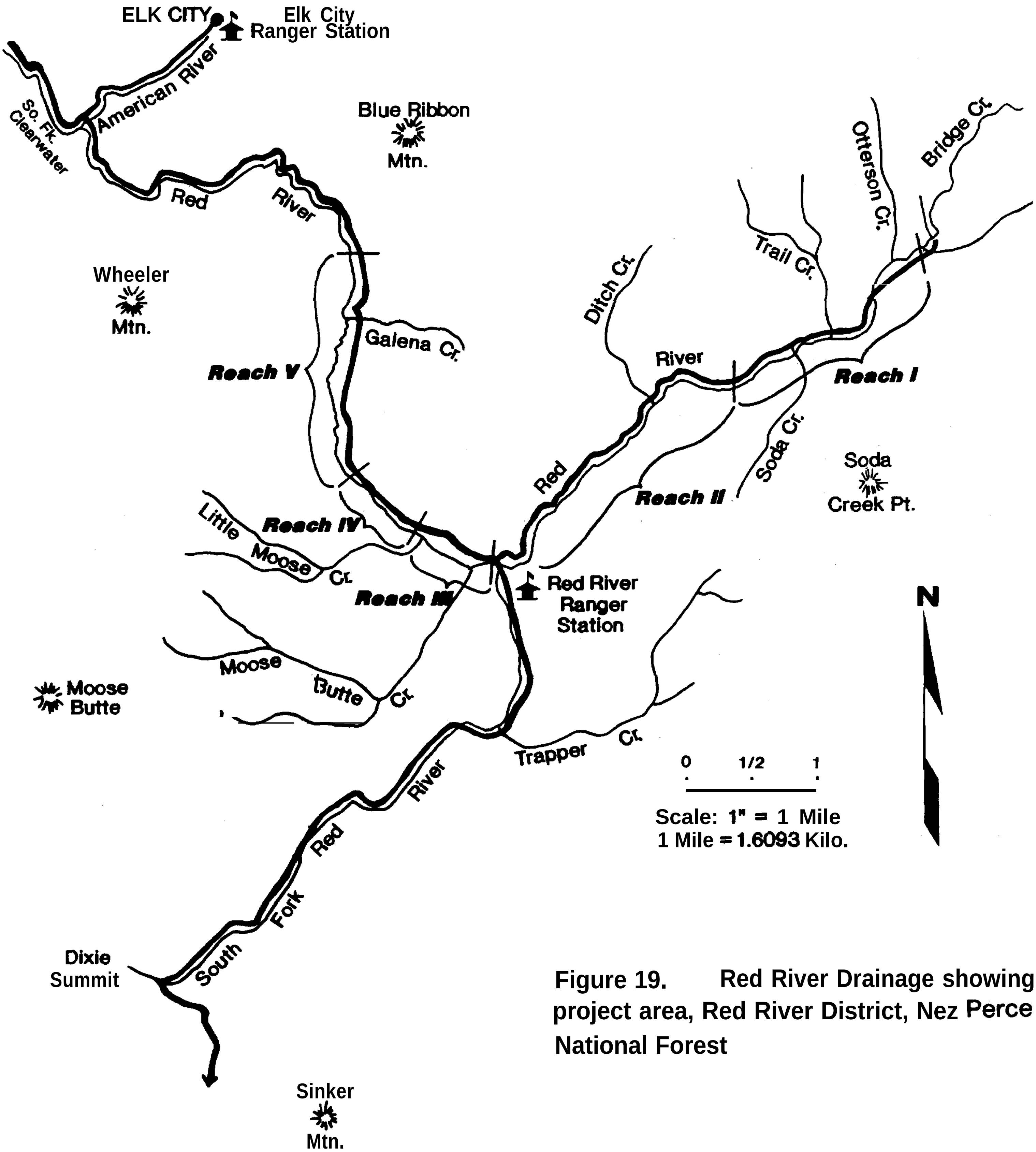


Figure 19. Red River Drainage showing project area, Red River District, Nez Perce National Forest

Historically, westslope cutthroat trout, bull trout, mountain whitefish, northern squawfish (Ptychocheilus oregonensis), sucker, longnose dace, speckled dace and sculpin were found throughout most of Red River's tributaries. Chinook salmon and steelhead trout utilized the main river channel, and some native rainbow trout may also have been present. Rainbow and brook trout were planted in the early 1900s and became established in the system.

Project **Area and Reach Description:** The project area includes approximately 30 kilometers of mainstem stream channel, about half of which flows through privately owned land. **Five** reaches were defined based on property ownership and similarities in channel morphology (Figure 19).

Reach I, in Upper Red River, flows mostly through privately owned meadows, although a small portion of it lies on Forest land. In upper portions of Reach I, where the riparian area has not been grazed by stock, the channel is relatively narrow and deep (a C6 channel type [Rosgen, 1985]), and overhanging banks are prevalent. With the exception of its sediment load, this upstream portion of the reach appears to be in near-pristine condition. Lower parts of the reach, however, especially the private lands, had been heavily grazed and were subject to severe bank erosion (Figure 20) (A conversion from a C6 to a C3 channel type had occurred [see Rosgen, 19851.) In fact, up to 200 tons of sediment were once estimated to erode annually from banks along one portion of Reach I. Problems identified for Reach I in the January 1984 amendment to the USFS/BPA agreement were eroding banks, lack of overhanging vegetation, and lack of shade.

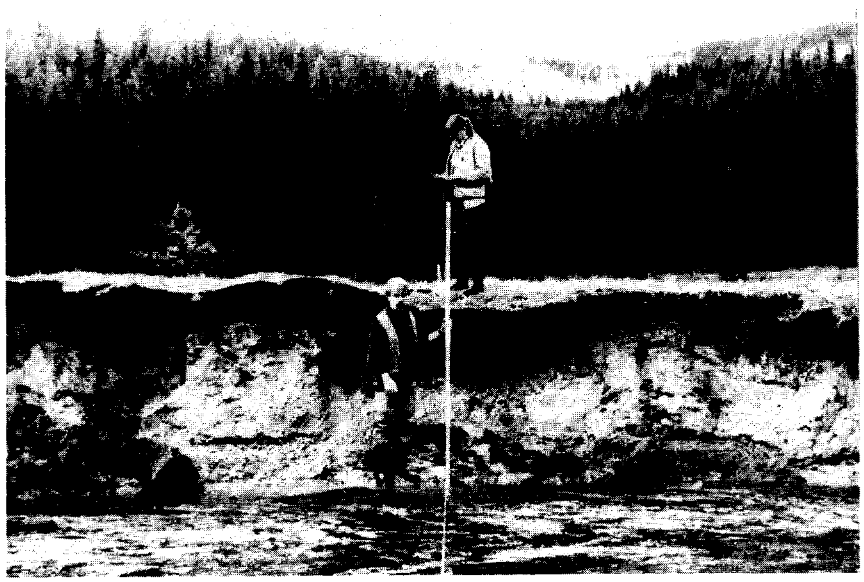


Figure 20. Eroding banks, Reach I, Red River.

Reach II includes the river from the lower edge of Reach I to the Ranger Station. About half of the riparian acreage of Reach II was harvested by a group selection cut in 1982. The reach was also included in the Red River grazing allotment from the 1920s to 1983. Timber harvest and the adjacent County Road 234 left this reach with insufficient numbers of active and potential debris (Figure 21). Some bank erosion **was** also occurring. Problems identified for Reach II in the USFS/BPA agreement (1/84) were eroding banks, extensive areas without over-wintering habitat (especially pools), and a lack of shade.

Figure 21. County Road 234, adjacent to Red River in Reach II.

Reach III is a privately owned meadow immediately downstream of the Ranger Station, part of which was dredge mined and subsequently realigned and straightened. In conjunction with grazing and a corresponding removal or weakening of deep-rooted woody shrubs on the banks, this resulted in an overwide, shallow channel with few pools, little habitat diversity, and an accelerated rate of bank erosion. Problems identified for Reach III in the USFS/BPA Agreement (1/84) were eroding banks, a lack of overhanging vegetation, and a lack of instream cover.

Reach IV, the 'canyon" reach between the two meadows downstream of the Ranger Station, was significantly altered by dredge mining. Fine floodplain materials which were left on the southwest bank when this reach was mined were subject to undercutting where the stream flow impinged upon them. Coarse dredge tailings were piled on the opposite bank, and although there were lodgepole pines growing on them in many places, their angle was such that vegetation did not overhang the channel. Unlike the meadow reaches, dredging left this section of the river with many deep pools. Problems identified for Reach IV in the USFS/BPA agreement (1/84) were eroding banks, little overhanging vegetation, few overhanging banks, and a lack of instream cover.

Comparison of aerial photographs taken in 1935 and 1984 indicates that dredge mining and channeiization shortened Reach V (the highly sinuous meadow reach in the lower Red River meadows) by approximately 60 percent. The transition between the uppermost mined area and the downstream unmined area is abrupt, and sedimentation at the boundary had caused a domino effect of sediment deposition and bank erosion which contributed to destabilization of the entire reach. Reach V's meadows were also hayed and grazed prior to project activity. Problems identified for Reach V in the USFS/BPA agreement (1/84) were eroding banks, lack of overhanging vegetation, few overhanging banks, lack of shade and a lack of instream cover.

It is some 10 km from the downstream end of Reach V to the mouth of Red River. This section (not in the project area) is not considered to offer particularly good spawning habitat. Furthermore, it is quite heavily dredge mined. and any improvements would be subject to dredge mine activity. It was felt that project activity would provide greater benefit in Reaches I through V.

Section III: Instream Structures

All of the “standard” instream structures were installed in Reaches II and IV, primarily because both are USFS-owned, and were immediately available for project work. Totals include 28 log weirs, 42 rock weirs, 46 deflectors (rock, log and series), 63 boulder complexes averaging three boulders each, 11 k-dams, 41 bank cover structures and 88 pieces of anchored woody debris (Table 6). In Reach II, these structures were installed to correct a lack of pools and overwintering habitat, and to provide cover and replace acting debris. Since deep pools already existed in Reach IV, much of the structural work there was aimed at providing instream cover.

Table 6. Red River instream structure accomplishments by reach.

Reach II	
28 log weirs 11 k-dams 65 trees anchored as large woody debris 20 log deflectors 21 wing deflectors (4 series) 4 gabions	40 rock wiers 13 boulder complexes 9 root wads anchored as large woody debris 2 rock deflectors 38 bank cover structures
Reach IV	
3 bank cover structures 50 boulder complexes 2 rock weirs	3 log deflectors 14 anchored pieces of large woody debris 1 rock deflector

Installation of the structures usually required a hydraulic excavator. Individual elements of the structures were sometimes secured to bedrock or existing boulders with three-eighths to one-half inch galvanized cable. The cable was fastened using a gas-powered rock hammer drill manufactured by Hilti, and Hilti’s Cl 00 bonding material. Much of the work, like placing filter cloth and wire mesh, was completed by hand. Actual installation methods varied according to the conditions, For instance, in some cases, the fill behind a log weir was supported by 2 X 2 inch wire mesh and filter cloth, in others by planking, and in still others fill material was placed behind the logs without additional support. Boulder weirs were constructed in either an upstream V or downstream V configuration. Cover logs were sometimes placed parallel to the flow and sometimes at an angle to it, sometimes cabled and sometimes buried in the bank.

Structure success varied according to structure type and placement. Some of the structures performed as expected, and now provide quality resting and wintering habitat for adult and juvenile salmonids (Figure 22). USFS personnel have observed that the deep, created pools are heavily used by adult chinook (Moroz, pers. comm.), and that adults also frequently rest behind the boulders placed in pools in Reach IV.

Figure 22. Large woody debris installed for cover.

Some structures, however, especially those that caused the channel to widen, became areas where sediment settled and collected. Platts et al. (undated), while discussing a structure-related improvement in stream depth, percent pool, bank water depth and pool quality, noted an increase in fine sediments associated with the structures. “Increases in fine sediments,” they observed, "... were probably associated with the increased pool-riffle...ratio causing higher depositional processes.” In Red River, where sediment deposition is thought to be a key limiting factor to salmonid survival, structures which increase the width:depth ratio (log weirs, rock weirs and downstream V’s) have not produced entirely positive results. They may indeed have created pools, but they have also reduced the stream’s ability to transport sediment. Today, USFS specialists recognize that in streams with high bedload sediment yields, the benefits of creating plunge pool habitat with weirs must be weighed against the structures’ tendency to overwiden the channel and induce sediment deposition. It is now felt that more emphasis should have been placed on structures that not only provide winter and resting habitat, but help to move sediment through the system, rather than collect and hold it. These opinions were echoed in a review of the project work by D. Rosgen. Wildland Hydrology Consultants, in 1989 (Rosgen, 1990).

An example of this kind of approach is a series of low wing deflectors alternating on opposite banks (Figure 23). Water flow, constricted by the deflectors, scours a long trench pool of consIderable value as fish habitat, without reducing the stream's ability to flush sediment from the system. Four of these series were constructed in Reach II in 1986. All four now provide quality habitat in areas that were formerly composed of homogeneous riff le/run sequences.

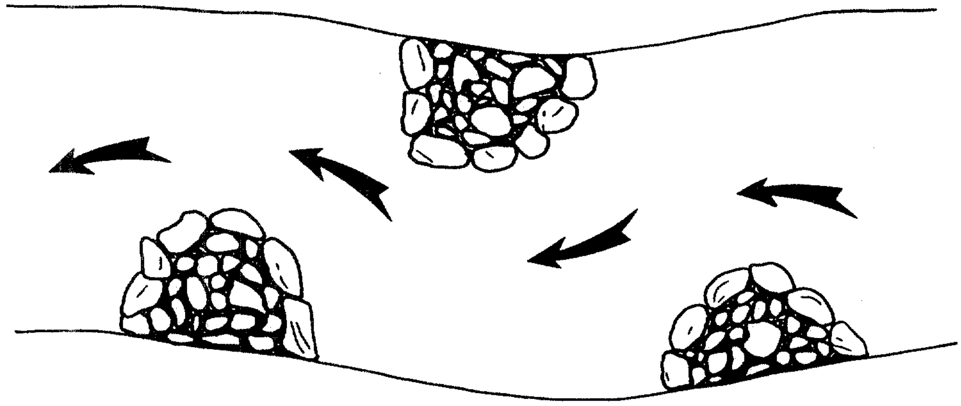


Figure 23. Alternating wing deflectors creating a natural meander and trench pool.

Structure Maintenance Requirements: A thorough examination of structure condition was conducted in Reaches I, II and IV in the summers of 1990 and 1991. According to these surveys, 82 percent of all instream structures were functional, although about one-third of both log and rock weirs, and one-fifth of the deflectors required some level of maintenance (Table 7). Some of the structures were in fact determined to be ineffective, and need to be scheduled for redesign or removal.

Table 7. A breakdown of current instream structure status by structure type.

Structure Type	Satisfactory		Requiring Maintenance		Ineffective	
	No.	%	No.	%	No.	%
log weir	16	57	10	36	2	7
k-dam	7	64	4	36	0	0
rock weir	26	62	14	33	2	5
boulder complex	63	100	0	0	0	0
anchored debris	70	79	1	1	17	19
bank cover structures	8	20	13	32	20	49
log deflector	7	30	1	4	15	6.5
rock deflector	2	100	0	0	0	0
wing deflectors (4 series)	21	100	0	0	0	0
TOTALS	220	69	43	13	56	18

Where this many structures are installed, it is not unexpected that a few should fail or require some reconstruction, Many of the Red River structure failures were due to factors similar to those that caused Crooked River structure failure. The filter cloth backing in several log weirs tore, so that water flowed underneath, instead of over, the logs. One weir had been placed at a slight angle to the flow, and water had been forced into the bank on one side. As in Crooked River, several of the downstream V weirs were found to force water off the V sides, and into the banks below the structure. Several weirs had been located where banks were too shallow to prevent water from flowing around the structures and eroding bank material.

Figure 24. Upstream V weir.

The majority of the ineffective structures were ones that had been installed to provide cover. These were bank cover structures, log deflectors and anchored woody debris. The latter two, deflectors and debris, tended to shift from the areas in which they were originally placed because of inadequate anchoring, or changes in flow. Bank cover structures were composed of a single log placed parallel to the bank, and held by perpendicular logs anchored into the bank. While in some cases these structures had filled with vegetation and were providing an artificial undercut bank exactly as hoped, in a number of cases water flowing into the structure eroded bank material behind the logs. Nez Perce National Forest specialists, after observing the effects of this kind of structure, would now recommend cover structures that do not interfere with natural changes in bank configuration due to seasonal and annual fluctuations in flow.

Some maintenance work has been completed. Four downstream V weirs were changed to upstream V weirs in 1991 (Figure 24), and several inappropriately located structures were removed, and the banks reshaped and seeded.

Section IV: Side Channels

To provide additional over-wintering and summer rearing habitat for juvenile salmonids, over 1,550 meters of side channel were created adjacent to the main Red River channel. In 1985, 98 meters of side channel were excavated with a small track-mounted backhoe (John Deere 555-D), and 175 meters of three previously existing side channels were opened and improved (these were generally old oxbows that had silted closed). Another 85 meters of side channel were excavated in Reach II in 1986, and slight maintenance was required on the sidechannels created in 1985. In 1988, permission was granted for side channel construction on private land in Reaches I and Ill. That year, six separate side channels were constructed: 550 meters in Reach III (two channels), 244 meters in Reach II, and 275 meters in Reach 1 (three channels). Another side channel was constructed in 1991 to provide inlet and outlet routes for a pond excavated in Reach III that year. The pond, which is approximately 150 X 25 meters, lies adjacent to an area of similar size that is also submerged at high flows--at low flows, this area remains marshy. The pond and the marshy area, along with the side channels themselves, add some 8,960 square meters of wetlands habitat to the Red River system. (For additional information regarding 1991 project work, consult Appendix A.)

High quality summer and rearing habitat has resulted where the created side channels were constructed with a gradient sufficient to flush the sediment that enters them. Other side channels, which are too wide or too shallow in gradient to flush themselves of sediment, generally provide good summer rearing habitat, but limited winter rearing, due to their high levels of fine substrate and corresponding lack of depth and cover.

Two other side channel design characteristics were found to be inappropriate for a stream that transports as much sediment as does Red River. In most cases, a log weir or other structure was placed immediately below the new channel intake; these structures were meant to encourage steady flow of water into the newly created channels. Instead, the structures slowed the water and encouraged sediment deposition at the inlet, so that at low flows, water can no longer enter the channel. A second problem is that channels constructed in 1988 were equipped with intake culverts which rested on the channel bottom, or in some cases, were partially buried in the stream bed. These culverts permit large amounts of sediment to enter the side channels, where, in channels unable to flush it, it remains.

In 1991, in an experimental attempt to minimize side channel sediment deposition, a board was fixed across the lower half of the inlet side of one of the problem culverts. If this decreases the amount of sediment entering the channel without overly reducing the flow, the District may try this same method on other channel inlet culverts, In Reach Ill, one of the intake culverts was replaced with a bottom-board headgate structure designed to minimize the amount of sediment entering the channel. This structure will require careful monitoring, however, to maintain desired flow volumes in the side channel as stage in the main river varies. Otherwise, problem channels could be improved by sodding the banks and/or intense planting efforts to narrow the channel. Manual removal of the fine sediment using a portable dredge may also be possible. Hydrologic designs for any future side channels should take into consideration the physical characteristics necessary to prevent unwanted sediment deposition.

Despite variations in success of some of the Red River side channels, USFS specialists have observed high numbers of juvenile salmonids using the channels, and feel that they add valuable rearing habitat to the system. Hillman noted significant use of a side channel for winter habitat in Reach II (Hillman, 1986). Some concerns were raised in the 1989 annual report to BPA that the side channels may freeze solid, and therefore be unsuitable for winter use. Observations during the winters of 1989/1990 and 1990/1991 revealed that while many of the side channels freeze across the top, they do not freeze solid.

Section V: Bank Stabilization

Bank erosion is considered to be a primary contributor of sediment to Red River. Accelerated rates of bank retreat have occurred in most places because of dredge mining and grazing, although in Reach II, they are due to an unnatural constriction of the channel by County Road 234 (Figure 21). Bank stabilization efforts took several forms, among them rip rapping, cover sill structures and **a** native material revetment (Table 8). In addition, many of the bank cover structures have reduced bank erosion as well as provided instream cover.

Table 8. Bank stabilization in Red River by year.

Year	Area Stabilized	Reach
1983	68 m	Reach II
1984	838 m^2	Reach II, Reach V
1985	43 m^2	Reach II, Reach V
1986	480 m^2	Reaches II, IV & V
1987	40 m^2 plus 3 structures	Reaches I, II
1988	1 structure	Reach I
1991	460 m	Reach III

Rip Rap: In 1984 and 1985, eroding banks in dredged areas of Reaches IV and V were rip rapped with large boulders. Rip rapped areas and the opposite banks were seeded and sprigged with willows, and one area was completely fenced.

At two sites, the rip rapping stabilized the banks as intended, and is now also providing instream cover (Figures 25 and 26). In one stretch of Reach V, however, individual or clustered boulders were not embedded deeply enough on the outsides of meander bends; bank erosion has left boulders isolated by bank retreat.

Figure 25. Unstable bank in Reach V, Red River, before bank stabilization in 1984.

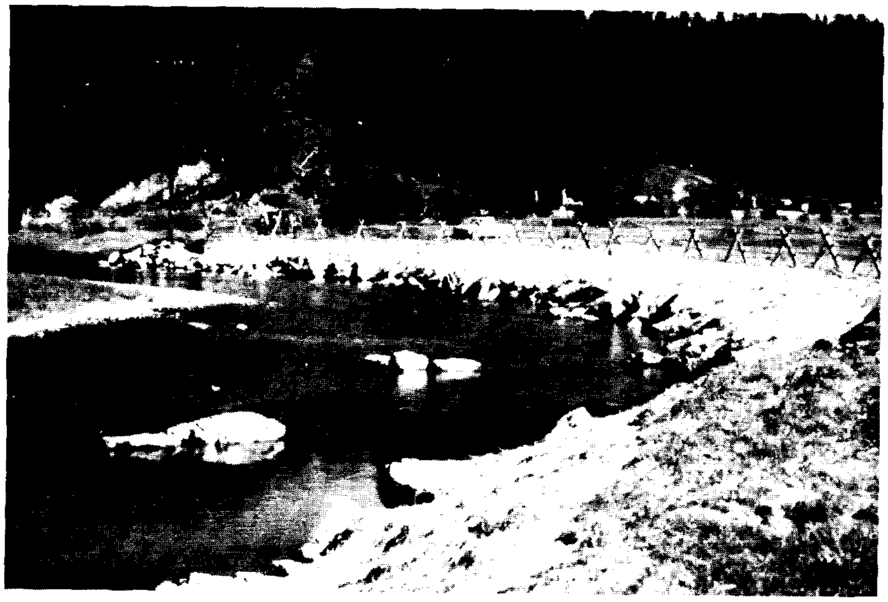


Figure 26. Same section of bank in Reach V. after **bank stabilization in 1984.**

Cover Sill Structures: In 1988, ten cover sill structures (See Seehorn, 1985) were constructed on **private** ground in Reach I (Figures 27 and 28). The cover sill structures were designed to stabilize **eroding** banks on the outsides of meander bends as well as create artificial overhanging bank cover (until deep-rooted vegetation is re-established). They were seeded, mulched with erosion control matting, and **densely** planted with alder, dogwood, and willow, and most were fenced after construction.

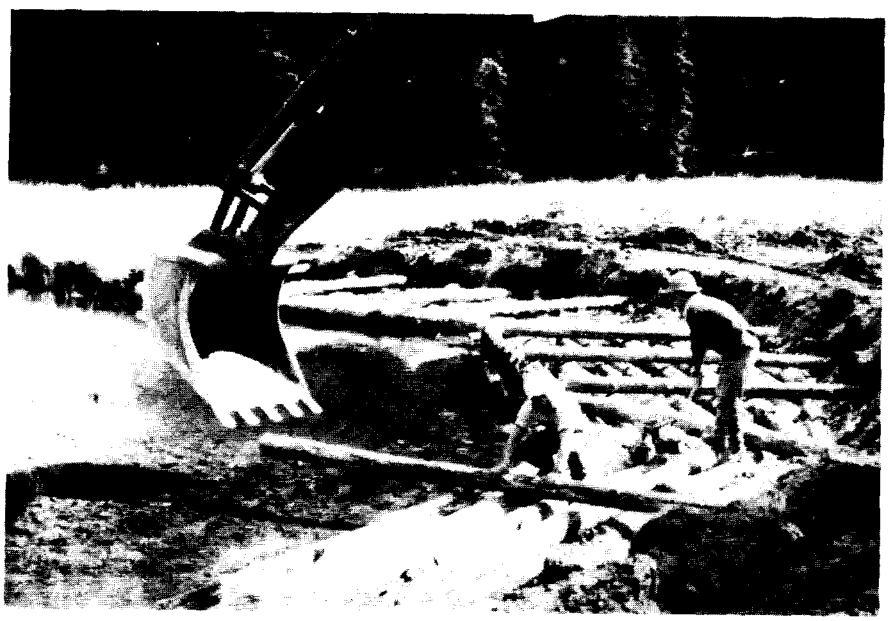


Figure 27. Construction of a cover sill structure in Reach I, 1988.

Figure 28. Shortly after construction of a cover sill structure in Reach I, 1988.

The cover sill structures have indeed reduced sediment input to the river from the accelerated retreat of .9 to 1.5 meter banks. However, a number of them were built at lower than bankfull stage, so that high flows annually overtop them, and erode the lowest part of the filled bank material. This fact reinforces the need to identify bankfull elevations and to design structures accordingly, especially those receiving the impact of turbulent flows on the outsides of meander bends. A few of the structures were not extended far enough down the bend, so that the locus of erosion has shifted downstream. In addition, because topsoil was not salvaged and redistributed, revegetation has been slow. Stock trampling and browsing also damaged those structures that were not fenced, or were fenced inadequately. While the problems have not rendered the structures ineffective, some reconstruction and topsoiling to promote quicker establishment of deep-rooted shrubs is required. This work, along with some additional required fencing, will be completed in 1992, as funding permits.

Bank Stabilization Logs: Logs were used in two ways to stabilize banks above the high water mark. In Reach II, eroding banks 1.2 to 1.8 meters in height were essentially terraced with a series of logs embedded in the bank face. The increased stability provided by the logs allowed vegetation to re-establish itself; this treatment is considered a success.

On a larger scale, logs were also used to terrace four to five-meter slopes in Reach !V. Here, dredge mining had left mounds of gravel piled on one bank and mounds of earth on the other. Boulders placed at the toe of the earth, and logs anchored across the face of the mound, have helped to stabilize the area so that seeded grass and planted shrubs can take hold.

Native Material Revetment: Another type of bank stabilization structure was constructed for the 1991 "Mullins" project in Reach Ill (Appendix A). Like the cover sill structures, it was designed to stop bank erosion until deep-rooted vegetation is re-established. It differs, however, in that it was built with natural materials; the result is an intricately interwoven lattice of logs, rootwads with 3.5 to 4.5 meter boles, and boulders to counterweight and wedge the wood. The rootwads were placed facing the flow so as to induce scouring of deep pools beneath them for overhanging cover. These revetments extend along 460 meters of bank in Reach Ill, in an area affected by dredge mining and channel straightening. They are discussed more fully in Appendix A.

Section VI: Riparian Area Revegetation and Fencing

Between 1983 and 1990, about 10,000 hardwood shrubs were planted in Red River riparian areas: Utah honeysuckle (Lonicera utahensis), Russian olive, willow, **aspen** (Populus tremuloides), green ash (Fraxinus pennsylvanica), blue elderberry (Amelanchier sp.), cottonwood (Populus trichocarpa), red osier dogwood and alder (Alnus incana) (Table 9). In addition, lodgepole pine, spruce and Douglas-fir were planted in 1983, and 500 Douglas-fir and Englemann spruce seedlings were planted in 1988.

Willow was taken as cuttings from locally established vegetation. Willow 'sprigs' were planted immediately into raw, eroding banks, very near the water table. Other shrubs, whose natural habitat is higher on the bank, were planted accordingly. As each of these shrubs was planted, an area about 35 X 35 centimeters was cleared of heavy grass cover (a process known as 'scalping").

The willow has clearly been more successful than other shrub species, while native species obtained from nurseries survived in greater numbers than non-native species. Non-native species, like Utah honeysuckle, green ash, Russian olive and cottonwood, are not now present in significant numbers. Blue elderberry success is difficult to monitor because the species occurs naturally in the area, and planted shrubs cannot be distinguished from natural regeneration. Seventy-five to 80 percent of the large aspen survived in **areas** where it was fenced.

Despite the "scalping," or removal of grass where shrubs were planted, grass was usually so well re-established by the season's end that it had a negative impact on the shrubs' survival. Competition from grass and damage by gophers have been the primary causes of mortality in planted shrubs. The conifers planted in 1988 were two-year old bareroot stock, and probably because of their age and stature, survived in greater proportions than the containerized shrub stock.

All disturbed areas were heavily seeded and fertilized, and where needed, mulched with straw or erosion control matting. Seed mixes were of a standard Forest Service variety containing approximately 37 percent pubescent wheatgrass (Agropyron pubescens), 22 percent annual rye, 16 percent orchardgrass, 10 percent hard fescue, 10 percent reed canarygrass and three percent white Dutch clover. **Seed was** applied at an average rate of eight lbs/hectare (20 lbs/acre). Most areas were fertilized with a 25-10-o-7 fertilizer mix at about 40 lbs/hectare (100 lbs/acre).

Fencing: To protect planting and seeding efforts, and also to prevent structural damage to banks, 750 meters of riparian fencing were installed in Reaches II, IV and V (Table 9). (Additional fencing is scheduled for Reach III in 1992.) Fencing was constructed in a post and pole or a jackleg style.

Fencing was originally identified as one of the four objectives of Project 84-5 activity in Red River, and continues to play a critical role in the success of the bank stabilization structures. Unfenced bank stabilization and cover structures were several times damaged by livestock grazing and trampling. Furthermore, partial failure of several bank stabilization attempts illustrates that, in the long term, fencing is probably the most reliable way in which to assist bank recovery in areas where bank degradation is not a result of channel alteration (like dredging or channelization). Fencing can encourage natural healing and corresponding stability where artificial structures alone are a short-term solution. Fencing was also key to the success of the planted alder and willow; areas where alder and willow were completely fenced from domestic livestock show a significantly higher survival rate than areas that were not. USFS specialists feel strongly that the original intent to fence portions of Red River was valid, and, in cooperation with other agencies and landowners, are working to improve riparian grazing practices and generate support for fence construction and long-term maintenance on private ground in Reaches I, III, and V.

Table 9. Red River riparian rehabilitation accomplishments* by year.

Year	Fencing	Planting
1983	335 meters	6,440 meters of streambank (conifers and deciduous trees and shrubs)
1984	321 meters	1,670 shrubs
1985		115 red osier dogwood 120 Utah honeysuckle 50 Russian olive 500 willow cuttings
1986	90 meters	580 willow
1988		500 Douglas-fir/Englemann spruce 240 aspen
1989		3200 willow cuttings 190 alder 190 red osier dogwood 280 blue elderberry 15 green ash 160 native Carex "plugs'

* funded by BPA

Section VII: "The Mullins Project”

Project activity in 1990 and 1991 was focused on an effort that came to be known as "the Mullins Project,’ because it took place on private land in Reach Ill belonging to E. Mullins. In 1989, BPA funds were used to contract D. Rosgen, Wildland Hydrology Consultants, Pagosa Springs, Colorado. In Rosgen’s report to the Forest Service (Rosgen, 1990), he outlined a restoration plan which involved realigning the river to achieve a meander geometry, pool:riffle ratio and channel shape in equilibrium with bankfull flow and sediment load; constructing bank revetments using only native materials (logs, rootwads and boulders) to stabilize the outer banks at bends; and promoting the recovery of dense, deep-rooted riparian vegetation through intensive transplanting and fencing. The Red River District hydrologist refined the plan with assistance from Rosgen and Nez Perce National Forest engineers.

In 1990, much of the BPA-funded activity involved preparing for the Mullins Project. In July, a unit of the Idaho National Guard transported some 400 boulders to the project site from USFS rock pits up to 25 miles away. This weekend exercise for the Guard unit represented a cooperative donation equivalent to at least 5000 dollars. In addition, the Red River Ranger District donated logs and rootwads from an area of blow-down timber which would otherwise have been offered as a salvage sale. Other cooperators included the Shearer Lumber Company, which donated a sizeable number of rocks and logs, the Kelly Creek Flycasters, Potlach Corporation, Idaho Department of Fish and Game and the U.S. Fish and Wildlife Service.

Project work in 1991 accomplished the following things:

1. The channel was realigned to reduce the radius of curvature on three bends and slightly amplify the radius of curvature on a fourth,

2. A native material revetment was constructed to stabilize 460 meters of severely eroding bank, and to provide cover for adult and juvenile fish.

3. The length of the channel was increased by 46 meters (8 percent), the bankfull width decreased by 7 percent, the maximum bankfull depth increased by 23 percent, and, accordingly, the width:depth ratio decreased by 17.5 percent.

4. Vortex rock structures were placed in such a way as to control flow direction and grade, and scour holding areas for fish.

5. An inlet control pipe (on an existing side channel) was replaced with a treated lumber headgate to allow manual control of water velocity and depth in the channel, and to minimize sediment influx.

6. A second channel/pond complex was constructed, with a similar inlet control structure.

7. Mature native shrubs were transplanted from disturbed areas to new streambanks and floodplains. Over 3000 willow cuttings were planted throughout the Mullins Project Area.

As of April 1992, the project appears to be fully successful. Little bank erosion is now evident, and scouring is occurring as planned in association with the vortex structures and general revetment configuration.

Additional fencing and planting is scheduled for 1992. The Kelly Creek Flycasters, a Lewiston, Idaho sportsmen's organization, has volunteered to plant lodgepole that will be grown and donated by Potlatch Corporation. The area will be completely fenced, except for two stock access points which will be lined with a geotextile designed to protect banks during stock use. Appendix A contains an extensive discussion of the Mullins Project authored by the District hydrologist who directed the activity. It explains the project's objectives and implementation methods, and includes pre- and post-construction survey results.

Section VIII: Summary and Conclusion

Project 84-5 activity in Red River spanned nine years, and was conducted in support of fisheries augmentation by the Idaho Department of Fish and Game and the U.S. Fish and Wildlife Service. Project activity focused on habitat degraded by mining, grazing, road building and timber harvest, and was guided by project objectives outlined in the original BPA/USFS agreement.

One of these objectives was to increase rearing habitat for fish through installation of instream structures. Construction of various kinds of weirs, cover structures and current deflectors, anchoring of large woody debris and excavation of side channels combined to fulfill this objective. Eighty-two percent of the structures are currently providing additional habitat as intended, although thirteen percent of them presently require maintenance. Approximately 1,548 meters of side channel were constructed in Reaches I, II, and Ill. Several side channels provide both summer and overwintering habitat, but because of sediment accumulations, others provide only summer rearing habitat. The causes of this sedimentation include low stream velocity at the side channel inlet, improper placement of the intake culverts, and low channel gradient. Several previously described experimental methods are being used to reduce sediment accumulation in constructed side channels.

Another objective was to encourage the re-establishment of hardwood and conifer vegetation in Red River riparian areas. Between 1983 and 1990, over 11,000 shrubs and trees were planted on raw and eroding banks, and in conjunction with instream structure and bank stabilization projects. Willow and indigenous hardwood shrubs survived better than non-indigenous species, and conifers, probably because of their age and stature, survived better than many of the hardwood shrubs.

A third objective specified protection of Red River riparian zones with streamside fencing. In all, approximately 750 meters of riparian fencing were installed in Reaches II, IV, and V. Problems associated with acquiring riparian easements to allow for construction and long-term maintenance of fencing forestalled further fencing projects. In future, greater cooperation with other agencies will help to provide the kinds of agreements necessary to fully accomplish this goal.

A fourth objective stated the need to stabilize areas disturbed by previous dredge mining (Reaches Ill, IV and V). Specific projects included installation of bank stabilization logs, placement of boulders to provide instream cover and stabilize the toe of tailings piles, and seeding and planting to stabilize banks and provide bank cover. In Reach Ill, the project also included realignment of the channel to achieve equilibrium with bankfull flow and sediment loads. Bank revetments were constructed to stabilize the newly realigned channel, and to provide quality instream cover and overwintering habitat. Other long term stabilization in Reach III will be achieved through bank revegetation and fencing.

As a compliment to the stated objectives, several kinds of bank stabilization structures were constructed in areas not dredge mined. They included rip rap, bank stabilization logs (Reach II) and cover sill structures (Reach I). Bank stabilization logs were successful in stabilizing steep banks until vegetation could be re-established, and cover sill structures performed well when accompanied by fencing. Plans have been made for maintenance and fencing of structures damaged by stock.

Whereas certain elements of the Project 64-5 activity were only partially successful, the overall project affect has been an increase in fisheries habitat quality in Red River. Bank stabilization efforts, including specifically the fencing and revegetation, were successful in preventing substantial quantities of sediment from entering the system. Instream structures undoubtedly increased habitat diversity in the project reach. The fencing effort, while only partially meeting expectations, helped to illustrate the necessity for inter-agency cooperation and planning prior to commencement of project activities.

Further fencing and hardwood shrub planting is recommended. Paving County Road 234 would greatly reduce sediment input to Red River, and the reduced input, of course, would increase the value of work accomplished to date. Additional channel improvement, like that accomplished during the Mullins Project, is warranted on another 370 meters in Reach III, and some 6.5 km in Reach IV. These segments offer some of the highest potential chinook salmon and steelhead spawning habitat in the South Fork system, but have been severely degraded. Onsite habitat loss, as well as downstream sediment and water temperature impacts have resulted.

Establishment of a landowners association within the Red River drainage would create the structure necessary to coordinate future land use and enhancement efforts. The Soil Conservation Service has indicated an interest in establishing a Coordinated Resources Management group, but will need Forest Service support to bring it about. The Nez Perce National Forest has requested partial funding of these projects through the 1991 Northwest Power Planning Council, Columbia River Basin Fish and Wildlife Program amendment process.

The USFS/BPA Project 84-5 agreement was amended in May, 1986 to include modification of a partial barrier in Meadow Creek, Clearwater Ranger District, Nez Perce National Forest (Figure 29).

Project Area: Meadow Creek enters the South Fork of the Clearwater River at river kilometer 52.3. The stream lies entirely within the Nez Perce National Forest, with the exception of a 294-hectare (725-acre) area known as ‘McComas Meadows’ in Sections 25, 26 and 35, T 30N R 4E. The creek is approximately 24 kilometers long, and drains 9,770 hectares (24,115 acres). Populations of steelhead trout, chinook salmon, west slope cutthroat, eastern brook trout, rainbow trout and bull trout inhabit the creek.

The Meadow Creek watershed ranges in elevation from 701 meters (2,300 feet) at the South Fork to 1,829 meters (6,000 feet) at its headwaters, and consists mostly of grand fir habitat types (although Douglas-fir is found on warm aspects). Apart from McComas Meadows, steep side hills predominate within the drainage.

Meadow Creek is a relatively large system, and is considered to have excellent potential for anadromous fish production. Murphy and Metsker (1962) identified 17,079 square meters of spawning gravels in Meadow Creek, enough for 1,361 spawning pairs. However, they, as well as several others, identified a partial migration barrier near the mouth of Meadow Creek, consisting of a succession of boulder cascades some 200 feet in length. Although McComas Meadows was once a traditional site for Native American harvest of chinook and steelhead, observation in 1985 indicated that most steelhead and all chinook were being blocked and detained by these barriers (a few small steelhead adults, probably jacks, were observed passing through the barriers). It is possible that the barriers were created by a landslide subsequent to Native American fishing activity.

Some attempts to modify the barriers were made prior to this project. In the late 1970s, explosives were used to modify one waterfall and enlarge an existing resting pool. In 1984, other minor changes were made with additional blasting. Neither of these attempts, however, was effective in easing steelhead passage. Major modification was made difficult by restricted access to the area.

The Idaho Department of Fish and Game, recognizing that the barriers did not present a total block to fish migration, released some 1,772,000 steelhead fry into Meadow Creek between 1977 and 1980. In 1981, a hatching channel was constructed on North Meadow Creek; almost six million eyed steelhead eggs were planted in the channel from 1981 to 1988. In 1988, 100,000 chinook salmon fry from the Rapid River fish hatchery were released into the creek at points upstream from McComas Meadows.

Methods and Materials: J. Orsborn and T. Bumstead were contracted in 1985 to design a means to ease fish passage through the barriers. The contractors examined two possibilities: minor modification of the lower portion of the barrier to allow passage for steelhead only, and more major modification of the entire falls to allow passage for both steelhead and chinook. The latter alternative was chosen, and the contractors’ final report (1986) recommended building a series of small weir pools, enlarging several of the existing pools, and removing some of the boulders which impeded flows. Implementation of the plans began in 1986; only a few minor modifications from the contractors plans (Figure 30) were made.

Because the site is inaccessible to machinery, all of the work was completed by hand. D&B Drilling and Blasting of Dayton, Washington were contracted for explosive work, and were on the site for about a week

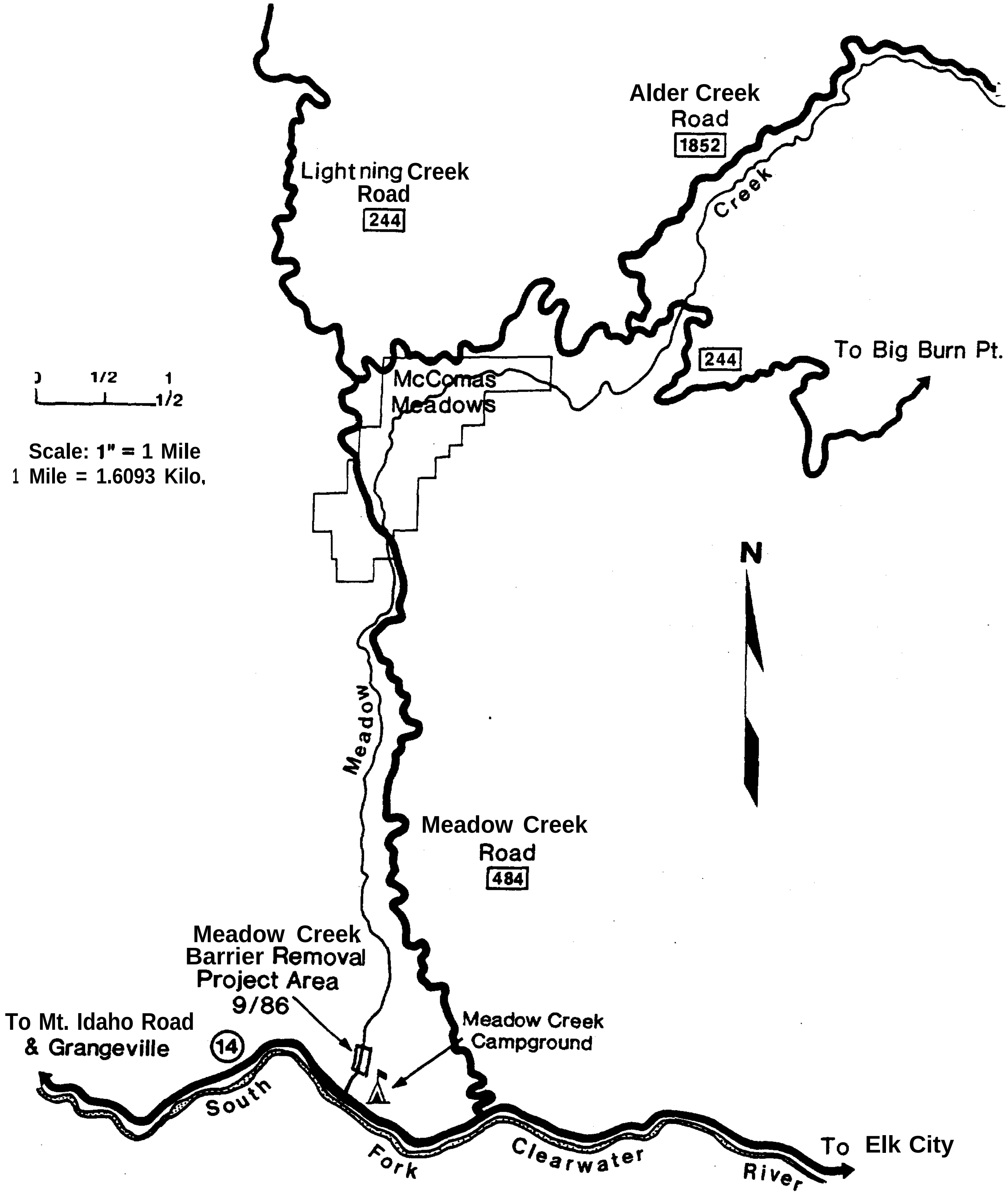


Figure 29. Portion of Meadow Creek Drainage showing project area, Clearwater District, Nez Perce National Forest

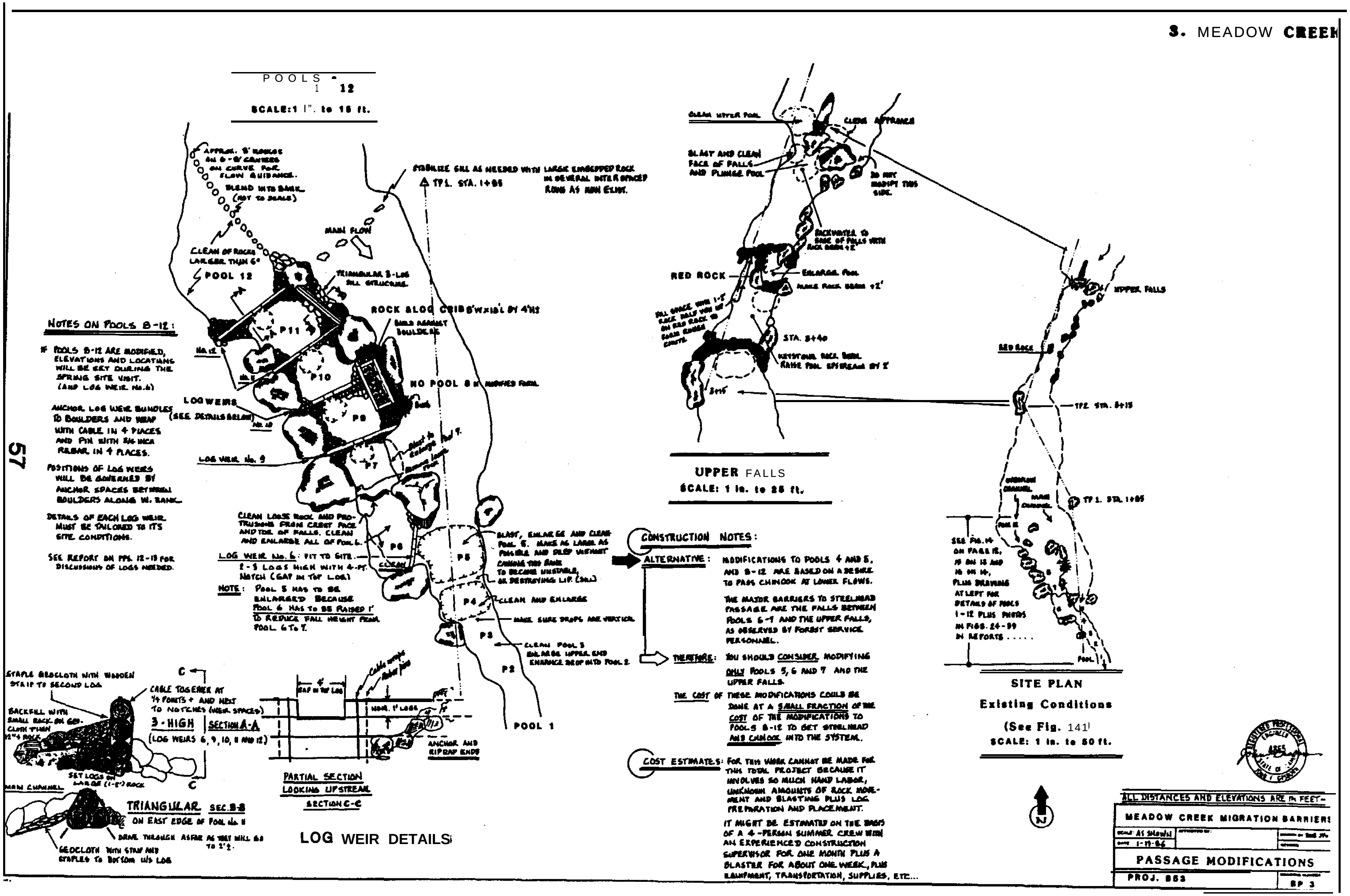


Figure 30. Site plan for barrier modification in Meadow Creek, J. Orsborn and T. Bumstead, contractors.

Most of the rocks designated for removal were basalt, and often wedged between granite boulders. Power Max 140 (boulder bombs) was used to remove the hard basalt rocks, and in some cases the surrounding granite fractured and split. After the blasting, rock fragments were removed from the pools manually. Some were used to fill gabions, others placed above the high-water mark. Logs and boulders used to construct the weir pools were moved into position with a chainsaw winch, block and tackle, log carriers and pry bars. Structure elements were secured to bedrock with a gas-powered rock hammer drill and three-eighths to one-half inch cable.

Results and Discussion: The project was completed in about four weeks in September of 1986, roughly half the time it was originally estimated to take (Figures 31 and 32). Annual maintenance involves cleaning the take-off pools and correcting any leaks under or around the log structures, and requires one to three days.

Removal of the Meadow Creek barrier makes available some 145,660 square meters of spawning, rearing and over-wintering habitat. Full seeding of the Meadow Creek system would produce 29,300 spring chinook and 22,000 summer steelhead smolts, and **a** corresponding escapement (and increase) of approximately 200 adults of each species to the South Fork Clear-water system. Subsequent to the barrier removal project, summer steelhead trout and spawning redds were documented above the project site, and steelhead were observed passing successfully through it.

Figure 31. Meadow Creek project site before project work, 1986.

Figure 32. Meadow Creek project site late in project work period, 1986.

In September of 1991, USFS approved plans for a land exchange by which it would acquire ownership of McComas Meadows. Grazing in the meadows has removed streamside vegetation, resulting in bank deterioration, high instream sediment levels and increased temperatures. (Much of the spawning-sized gravel in McComas Meadows is presently only marginally utilizable because of high cobble embeddedness.) If the land exchange occurs, USFS intends to initiate a major rehabilitation project which would consist of fencing, bank stabilization and revegetation. These activities would increase the quality of the habitat newly available to anadromous fish runs.

Water has been key to mining in the western United States since the first gold pan was put to use here. Methods quickly evolved to complex combinations of sluices and ditches. When miners began to discover deposits of gold in prehistoric river beds, sometimes high on the hillsides above present waterways, hydraulic placer mining was developed. Hydraulic mining was used as early as 1852 in Nevada County, California (Wagner, date unknown, in North American Gold Mining Industry News, 1985), but most of the hydraulic mining sites on the Nez Perce National Forest were worked between the turn of the century and the 1950s.

Hydraulic mining involved routing water from sources much higher in elevation than the claim. Forced into a canvas hose, the water, dropping in elevation, became highly pressurized (Figures 33 and 34). Reports of early Californian hydraulic mining include stories of men and animals killed by the force of the water at a distance of 200 feet from the nozzle. "A 50-pound boulder placed in the stream of water would be projected with the force of a cannon ball, riding the water for a considerable distance before falling" (Ibid.). The tremendous force of the water crumbled entire hillsides. The muddy water, containing boulders, rubble and "pay dirt," coursed down the slope where it was routed into a sluice box which settled the gold. Leaving the sluice box, the sediment-laden water drained directly into creeks and rivers.

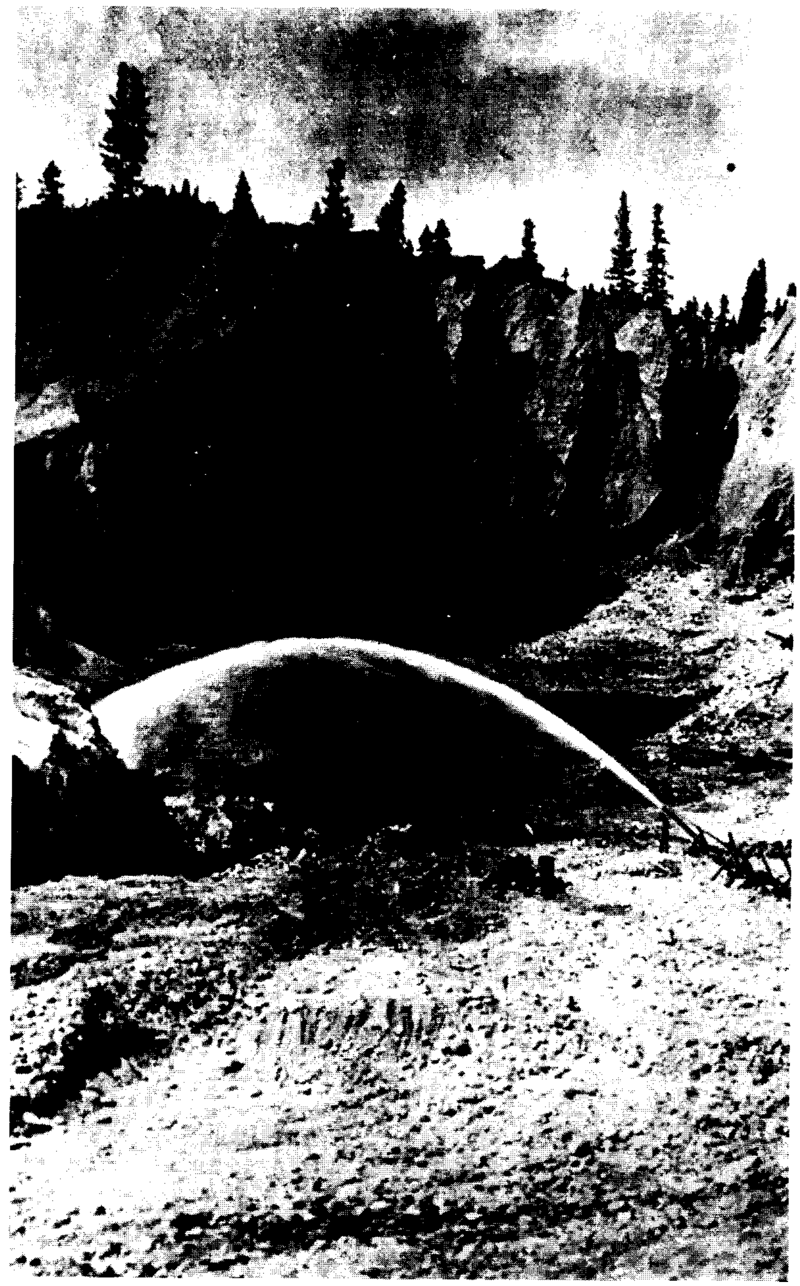


Figure 33. Hydraulic mining in Leggett Placer, Nez Perce National Forest, 1902.

Figure 34. Close-up of hydraulic mining in Leggett Placer, Nez Perce National Forest, 1902.

The huge pits which resulted from the hydraulic mining were called gloryholes. Decades later, many of the gloryholes on the Nez Perce National Forest look much the way they did when the miners left them. In many cases, steep headwalls have not revegetated, and sediment loss by erosion is still tremendous. However, the gloryholes have significant historical interest, and this fact should not be ignored during rehabilitation efforts.

A rough "feasibility study" conducted in conjunction with Project 84-5 identified twelve hydraulic mining sites on Forest Service and private land, listing a cost estimate for rehabilitation of each. However, as project work commenced, it became clear that initial cost estimates were almost ridiculously low. The original estimate for rehabilitation of the Haysfork Gloryhole, for instance, was 12,500 dollars. Current estimates now lie between 500.000 and a million dollars.

USFS personnel decided to focus project funds on four of the gloryholes, Haysfork Gloryhole, Cal-Idaho Gloryhole, Leggett Placer and Fisher Placer.

Haysfork Gloryhole

The Haysfork hydraulic placer mine (Haysfork Gloryhole) is located in the north half of Section 24, T 30N, R 6E, and drains into Newsome Creek, a major tributary to the South Fork Clearwater River (Figure 2). The pit lies at about 1,341 meters (4,400 feet) elevation, and is approximately four hectares (10 acres) in size (Figure 35). In addition, runoff from the gloryhole has physically affected a large area below the pit. The sparse vegetation in the gloryhole is dominated by lodgepole pine, grand fir, Douglas-fir and alder, much of which has been planted in various rehabilitation efforts. Annual precipitation at the site is about 76 cm (30 inches), of which 46 cm (18 inches) are generally snow.

The site is in the Border Zone of the Idaho Batholith, which is composed of highly erodible schists and gneisses, and some interjected granitic textured materials. Slightly compacted Tertiary Period sediments overlie the Border Zone rocks. This combination of soils, slope and concentrated water result in a site particularly susceptible to erosion. The R1/R4 Sediment Model and the Soil Conservation Service's Universal Soil Loss Equation both estimate that approximately 170 tons of sediment are generated annually from the gloryhole (Gerhardt, unpublished). Between 1987 and 1991, approximately 920 cubic meters of sediment reached sediment traps located 400 meters below the gloryhole, adjacent to Newsome Creek. Using a 1.16 tons/cubic meter conversion factor, this would equal roughly 1071 tons of sediment, or about 270 tons/year. (Tons/cubic meter conversion factors are highly variable; tons calculated using a conversion factor are very general estimations.) The facts that two of these years were well below average in spring runoff and that some sediment was undoubtedly trapped within the gloryhole seems to indicate that the model estimates are low.

Historical Background: While the Haysfork Placer was locally known by its current name (Kennedy and Morgan, pers. comm.), it was evidently also called variations of "the Old Montana.' Early reports contain no mention of a "Haysfork" mine or placer, but Bell (1908), Shenon and Reed (1934), and Reed (1934) refer to a mine they call "the Old Montana Placers," "the Montana," or "the Old Montana" that corresponds in location and magnitude to the Haysfork Gloryhole. In 1909, the mine was operated with four "giants" (nozzles), and appeared to be one of the most significant deposits in the district (Bell, 1909). According to Shenon and Reed (1934), between 459,000 and 612,000 cubic meters of interbedded gravel, sandstone and clay were removed from the placer between 1905 and 1915, yielding 317 ounces of gold and 29 ounces of silver. Water was brought to the site over Little Baldy Saddle from Pilot Creek: remains of the diversion ditch can still be seen from the Elk City Wagon Road (Morrow, pers. comm.). Sluice boxes emptied tailings directly into Newsome Creek after processing. Until 1984, upper slopes of the pit were much as the miners had left them in 1915, although massive erosion had undoubtedly occurred since then. The upper scarp, at 100 percent slope, was being undercut by wind and rain (Figure 36).

Rehabilitation Activity Prior to Project 84-5: In a memo **dated** January of 1963, then Elk City Ranger District Timber Management Assistant Lynn Mason recommended leaving the area to heal naturally. That spring, after he had witnessed the effects of a high intensity storm on the gloryhole, he changed his mind. In April of 1963, he issued a memo suggesting blasting of the steep, upper slopes, and a seeding and planting program. In 1965, the **Elk** City Ranger District issued the first detailed restoration plan for the gloryhole, which recommended that the slope of the gloryhole be reduced to less than 35 percent by "moving the earth from the lip of the glory hole into the hole" with dynamite, caps, ditching powder and dozer work, In addition, it recommended the construction of a series of contour trenches to help drain water from the area, and vigorous planting, seeding and fertilization, The "soil, when disturbed," according to the plan, "will not erode if treated with standard erosion prevention methods."

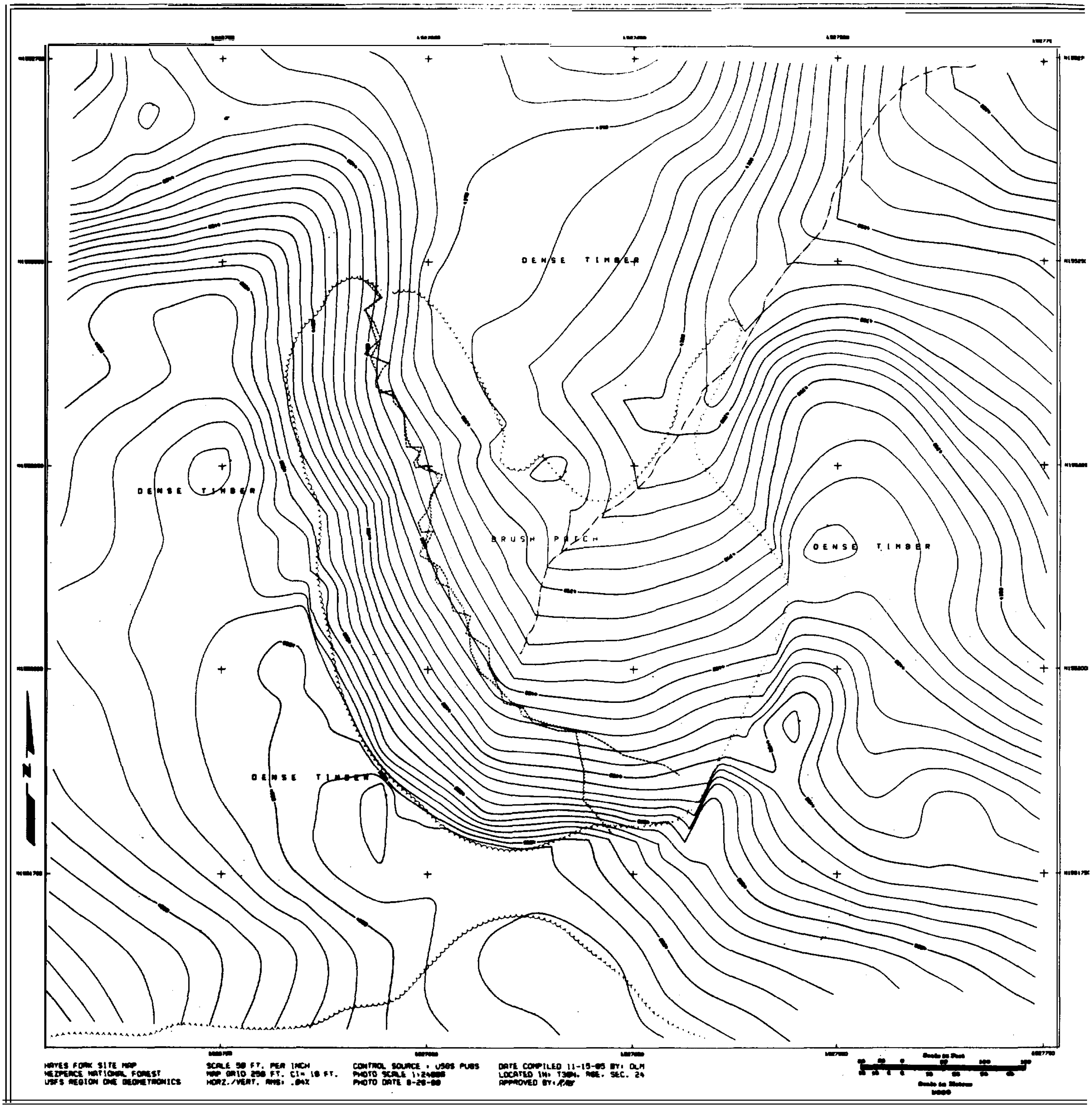


Figure 35. Haysfork Gloryhole, 1980.

Figure **36. Upper slopes of Haysfork Gloryhole. prior to project work in 1964.**

Funds were lacking, and the 1965 rehabilitation **plans were not,** for the most **part,** put into effect. Some Doug!as-fir may have been planted in conjunction with routine planting of a clearcut that had been **located** adjacent to the upper edge of the gloryhole in 1966 or 1967. In 1979, a field review resulted in a memo which included this statement: 'the Hays Fork Glory Hole represents a very difficult, if not impossible, rehabilitation task.' The memo did, however, suggest planting on the lower **slopes of the** gloryhole, **and** placing logs along the toe of the slope to catch sediment moving downslope. It also recommended consideration of sediment trap structures downstream of the mine site. It is not clear whether any action resulted from these suggestions, but certainly no major rehabilitation work occurred at this time.

In 1984, USFS funds were used to hire a crawler tractor (dozer) to cut back the upper slopes, and round out the resulting slope to an average gradient of about 50%. The dozer spent approximately 100 hours laying back the steep, upper slopes, and pushing fill into the gloryhole. Trees cut from the edge were pushed into the gloryhole along with the fill; this mix of earth and debris buried several springs in the existing face. A bench, approximately 10 feet wide, was built below the back-sloped area. A ditch on the inner side of the bench was designed to drain the sloped area, and was constructed to contain low erosion barriers about two and a half meters apart along the length of the ditch. The ditch emptied into wooded areas outside of the gloryhole, where the runoff spread out upon the ground.

In 1984 and 1985, at least 27 small check dams (between .5 and 1.5 meters high) were constructed in the stream channel at the base of the gloryhole. These utilized untreated trees from the site, which have subsequently begun to decompose. Several of the upper structures were filled within a year, and by the late eighties, all of these traps were full. Straw bales were also installed to help hold sediment.

After completion of the various stages of work, the slopes were heavily seeded. Alder and lodgepole pine were planted both above and below the bench. Shrubs above the bench are now growing fairly well in most locations, and in some areas below the bench the alder are presently over six feet tall. In many areas, however, massive erosion has carried the shrubs away, and buried them at the base of the gloryhole.

By May of 1985, problems with the 1984 work were already evident, The upper slope, above the bench, appeared to be recovering well (this upper section was still found to be stable in 1989). During the winter and spring, however, a mud flow had developed in the unconsolidated fill below the bench. The flow, which was about eight meters wide, extended from the toe of the slope 90 meters down the drainage. Much of the material had evidently accumulated in the check dams and around natural obstructions. However, an unknown quantity of the fill had clearly drained directly into Newsome Creek. The remaining unconsolidated material also showed signs of instability.

Memos from the summer of 1985 blame slope failures on the fact that the fill from the 1984 project was left in an uncompacted and oversteepened state, without subsurface drainage to intercept ground water seeping out of the old slope face. Furthermore, the winter and spring following the 1984 rehabilitation work were 30 percent below average in precipitation, according to the memos, and slope failure could have been significantly worse.

During the next few years, massive slope failure reshaped the gloryhole once again. While the slope above the bench remained in fairly stable condition, the fill material below the bench failed dramatically, leaving slopes as steep (and probably less stable) than the ones that originally existed (Figure 37).

Figure 37. Upper slopes of Haysfork Gloryhole, 1988. Note bench in upper pit, and newly planted lodgepole pine above bench. Also note failure of fill material in picture center.

USFS funds, in conjunction with an ongoing project in Newsome Creek, were used in 1987 to construct a channel to divert runoff from the gloryhole into two settling ponds. The ponds had been left by prior dredging in Newsome Creek, and were slightly deepened and enlarged during the 1987 reshaping. They were not lined, and runoff was meant to enter Newsome Creek from the second pond by filtering through the tailings. The ponds at that time had a capacity of approximately 918 cubic meters, and were immediately effective in collecting sediment from the gloryhole runoff. However, the location of the ponds, about 2.5 kilometers from the nearest Forest road, makes them difficult to clean. An old mining road makes the site marginally accessible to large four-wheel drive or tracked vehicles. (The road fords Newsome Creek six times, and is not passable by pick-up trucks.)

Project 84-5 Activity: The Project 84-5 agreement was amended in June of 1987 to include project work on several hydraulic mining sites. In the revised document, Haysfork was scheduled for "slope stabilization, revegetation and maintenance" totaling 12,500 dollars.

The first activity to employ BPA funding occurred in June of 1989, when Stensatter Druyvestein and Associates, of Missoula, Montana, were awarded a contra& to design, map and ground stake a stabilization and/or drainage plan for the Haysfork Gloryhole. The project objectives were to 1) stabilize and/or drain the seeps in the gloryhole, and 2) substantially reduce potential for mass erosion and surface erosion from the gloryhole. The contractor was to investigate the possibility of constructing a rock buttress at the toe of the fill slope created in 1984, as well as to supply another, separate alternative to address the problems.

Stensatter Druyvestein and Associates' draft report, submitted in September 1989, determined that the upper section of the gloryhole, above the bench, was stable and revegetating; that the middle section, where the bulk of the sidecast material from the 1984 project work lay, was structurally unstable; and that the lower section, at the base of the gloryhole, was generally stable except that the new material continually sliding and eroding from above prevented revegetation, which kept the area subject to ongoing surface erosion. (It was noted that some areas of this lower section were revegetating successfully.)

The contractor concluded that the rock buttressing proposed by USFS was "not compatible with the observed and expected means of slope failure" (that it would fail to stop translational mass slope failure) (Stensatter Druyvestein and Associates, 1989). It then proposed a second alternative which was to involve mechanical slope reconstruction, drainage control and revegetation.

Slope stability analysis conducted by the contractor indicated that a slope between 40 and 60 percent would be stable. The contractor's proposal suggested that the entire site be reworked to result in one continuous slope, benched throughout. The company suggested that fill material from the top of the site be hauled to the bottom over an access road to the north of the pit. Adequate compaction would theoretically **occur** as machinery moved across the fill material. Surface water would drain along the benches to areas of greater stability offsite. Two drainage systems would be installed, one to collect water from upper seeps, and a second to catch water at the toe of the slope.

USFS geotechnical engineers, hydrologists and other personnel identified a number of concerns regarding the contractor's alternative.

1. There was question as to the suitability of the area north of the gloryhole as a heavily used access route.
2. There was concern as to the suitability of the north and south sides of the site as discharge points for surface and subsurface water drained from the gloryhole.

3. The stability of the toe of the slope was questioned because the exact depth of the deposited sediment is unknown, and the plan would result in another 25-35 feet of fill in this area. Failure of this area would be drastic.
4. There did not appear to be adequate data to support the contractor's assertion that the gloryhole can be successfully drained and stabilized. Data was insufficient to estimate accurately the amount of earth it would be necessary to move, or to show that diverted water would not create additional erosion off site.
5. There was concern about the length of the drains proposed by the company to drain subsurface water. It was felt that a break in one of the drains might result in massive slope failure.

In February of 1990, the contract was mutually terminated. USFS personnel had concluded that full-scale stabilization and rehabilitation of the Haysfork Gloryhole was a project far greater in magnitude than originally anticipated. It was felt that more funding than that allowed by the USFS/BPA agreement would be necessary to fully address the problem.

Further Analysis: Despite the concerns, aspects of Stensatter, Druyvestein and Associates' plan warranted continued analysis. In May of 1990, several USFS personnel, including the regional geotechnical engineer, toured the site to assess Stensatter Druyvestein and Associates' draft stabilization plan. Particular attention was paid to concerns already identified by USFS personnel, especially those regarding the proposed drainage system. This group determined that water should be drained down the gloryhole, not across it, as proposed by the contractor. They concluded that water in seepage areas could be collected into a prefabricated drain, and transported downhill in a solid pipe to an established drainage at the toe of the slope. This group also suggested fencing to prevent livestock from entering the area, and construction of a snowfence along the edge of the adjacent clearcut to prevent the heavy snow buildups which resulted when snow blew through this gap.

Further consultation with two regional Minerals Reclamation Specialists, E. Farmer (R04) and N. Yogerst (R01) yielded another series of suggestions. Farmer recommended installation of lateral drains into the hillslope above the existing road which would empty into a 4-inch unperforated pipe in the ditch along the roadway. Above the 4-inch drain would lie an 8-inch perforated pipe designed to collect runoff from the road itself, and surface runoff from the hill above the road. Farmer recommended that two other roads be built across the surface of the gloryhole to allow for similar drainage plans.

The sediment dams in the stream channel leading from the pit to Newsome Creek concerned both the specialists. Thousands of cubic meters of sediment are currently stored behind these structures, and as they rot and fail, the sediment has the potential to directly enter Newsome Creek. In fact, a major storm event could result in a disastrous release of all of this material into Newsome Creek at once; a complete blockage of Newsome Creek in this kind of event is not an impossibility. Farmer recommended removing the sediments with a small-tracked excavator, and placing them on the channel banks. Yogerst, however, did not feel that the banks could accommodate the vast amount of sediment behind the check dams, and instead suggested bolstering the check dams with concrete and native rock or treated timbers.

Both experts noticed that fine clays appeared to be filtering through the gravel walls of the sediment ponds near Newsome Creek, and suggested the use of synthetic liners to alleviate this problem. Farmer also noted that the ponds are ill-placed and "drastically undersized," and recommended that they be redesigned. Until funds are available to do this, however, the ponds are clearly highly effective in collecting sediment as they are, although high flows would undoubtedly overtop the structures. It took four years for the traps to fill from the time of their construction, but two of those years were considerably below average in spring runoff, and in an exceptional year the traps might well fill in one season.

These sediment traps, or any others that might be constructed in the area, present another problem which must not be overlooked. It is exceedingly difficult to locate appropriate places to dump sediment removed from the traps. The site presently in use is almost full. Other level sites, where sediment could be stored without further erosion, are scarce. It would be beneficial to spread the sediments out on dredge tailings piles along Newsome Creek, but due to the limited access, it would be almost impossible to transport the sediment that far. Any future plans for sediment traps in the area must fully address these difficulties.

Yogerst's and Farmer's suggestions would need to be subjected to slope stability analysis, feasibility analysis and other kinds of scrutiny before being incorporated into a final plan. Many of the concerns regarding Stensatter Druyvestein and Associates' proposal would apply to these recommendations as well.

Work In 1991: During the summer of 1991, USFS used BPA funding to complete a series of rehabilitation activities as interim measures. (Some of the 1991 work was accomplished in the gloryhole itself, and some at the sediment traps where runoff from the gloryhole enters Newsome Creek [Figure 38].) In addition, the Elk City Ranger District submitted a separate project proposal to the Northwest Power Planning Council. This proposal requested 1.3 million dollars for an architectural and design contract for a stabilization plan, for implementation of that plan, and for maintenance of the project upon its completion.

Work in the Gloryhole

1. Prior to 1991, the only way to transport material to the gloryhole was by helicopter, or along a narrow skid trail with a slope exceeding 30 percent. To make the gloryhole more accessible, a 400-meter trail from Forest Road 1858 to the upper lip of the area was located and cleared. The trail is suitable for 4-wheelers with trailers. Supplies for the 1991 work (including concrete, posts and poles, straw, seed and fertilizer) were transported to the gloryhole on this trail.

2. Waterbars were installed on the new trail, as well as on the old skid trail, and the areas were seeded, fertilized and mulched.

3. A three-rail jack fence (with gates), 460 meters in length, was constructed around the top of the gloryhole. The fence will keep livestock off the site until it is satisfactorily revegetated. (The steep slopes will prevent livestock from accessing this area from the bottom of the gloryhole.)

4. Approximately .6 hectare (1.5 acres) above the bench were scarified with hand tools to allow better grass establishment. Approximately 1.6 hectare (four acres), including this area above the bench, were seeded and fertilized. An additional 1.2 hectare (three acres) of the grass and/or alder in lower portions of the gloryhole were fertilized, along with approximately .8 hectare (two acres) of the adjacent clearcut to encourage growth that will trap snow.

5. Crews constructed 15 meters of 3.5 meter-high snow fence along the edge of the clearcut adjacent to the top of the gloryhole.

6. Water was not draining properly from the ditch on the bench near the upper portion of the glotyhole, and steep cutbanks above the bench had sluffed. A Kubota KH41 was used to reshape the channel area in a 45-meter test plot. One portion of the channel was lined with concrete. A second was underlaid by perforated pipe and then lined with concrete. A third section was armored with erosion control matting and rocks, and the last was lined with rocks alone. Straw bales were anchored with reinforcement rods in an area of slumping; the area was then lined with erosion control matting and rocks. The area disturbed by the construction was seeded, fertilized and mulched.

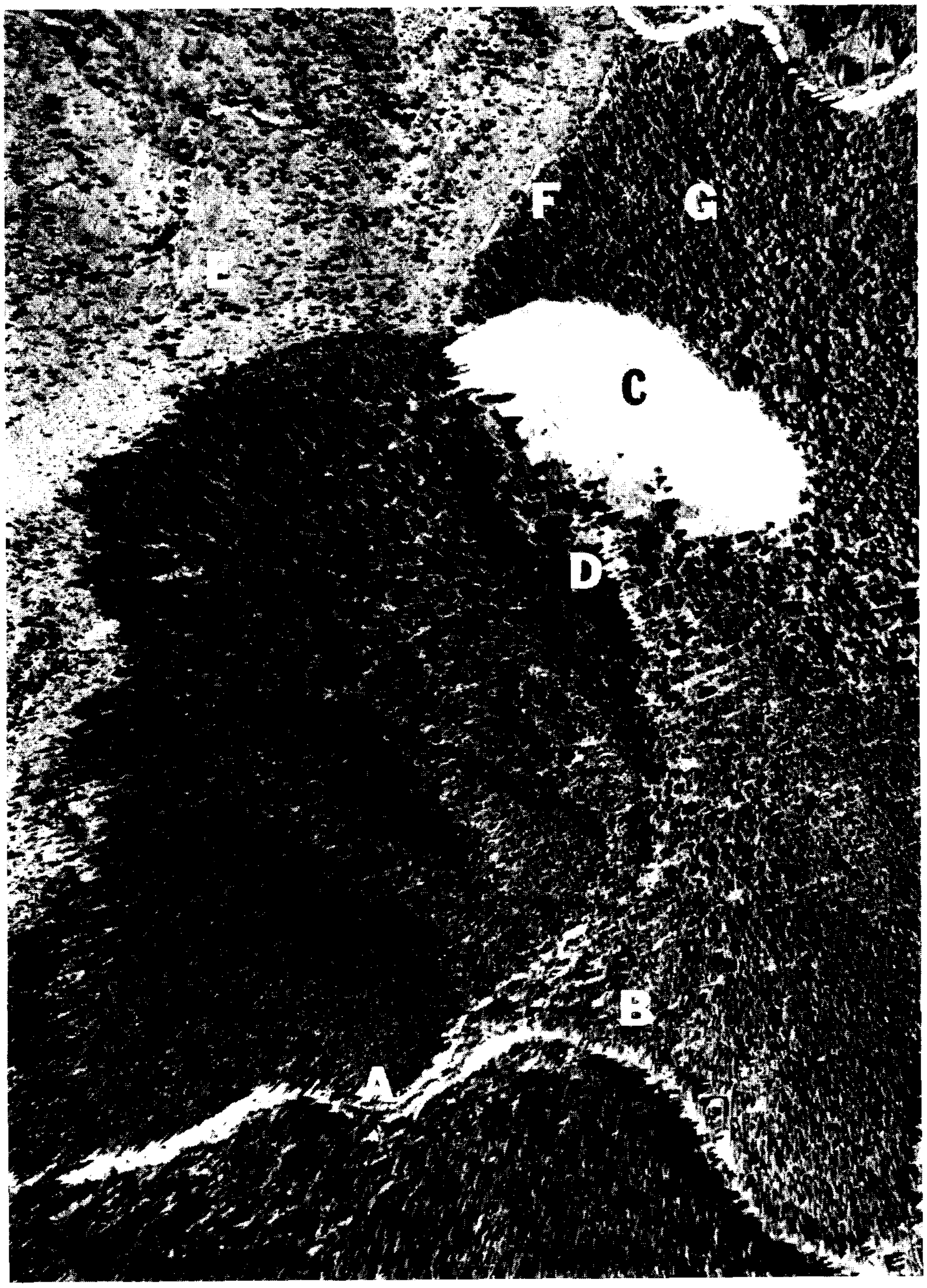


Figure 38. An aerial view of Haysfork Gloryhole, 1989. A. Site of sediment traps. B. Site where sediment removed from traps was dumped, 1991. C. Bench in gloryhole face, constructed in 1984. D. Site of check dams constructed in 1984 and 1985. E. Area clear cut in 1966 or 1967. F. Steep skid trail. G. Site of trail constructed in 1991.

Work below the *Gloryhole*

It was necessary to empty the creek-side sediment traps through which runoff from the gloryhole drains. Because of the terrain, machinery access was limited. The Idaho National Guard supplied four **all-wheel-**drive dump trucks, and the Forest Service contracted an excavator to load the trucks with sediment from the traps.

First, a site about 180 meters north of the traps was cleared for disposal of the sediment. The capacity of the site was limited to around 612 cubic meters this year, although as the saturated sediment dries, there will be additional available space. A ditch and berm were constructed along the lower sides of the dump site to contain the fill and prevent its erosion. The ditch will direct pressure from the fill down into the ground, instead of across the ground into the berm.

About 612 cubic meters of sediment, in 118 truck loads, were removed from the two traps. The upper trap was completely emptied, and about half of the second was emptied before the capacity of the disposal site was reached.

Twenty loads of rock were placed in a low spot in the road that bordered the upper sediment trap. This will not only help to prevent breaching of sediment-laden water into **Newsome** Creek, but increase the capacity of the pond by about 150 cubic meters,

In addition, a third sediment trap, with a capacity of 76 cubic meters, was constructed above the two existing traps. (All three traps now have the ability to trap and hold approximately 1,150 cubic meters of material.) The ditch that collects and funnels the runoff from the gloryhole to the sediment traps was deepened and improved. Thirteen trees felled during the work were placed in **Newsome** Creek for fish cover. All disturbed areas were seeded, fertilized and mulched.

The Future: Every one of the specialists who has witnessed the **Haysfork** Gloryhole agree that action must be taken to decrease ongoing erosion, and reduce the potential for a major, disastrous event. The initiation of the Stensatter Druyvestein and Associates contract was valuable because it helped to illustrate the complexity and immensity of the situation. Subsequent review has **revealed** some potential courses of action, but a great deal of further analysis will be necessary before a scientifically sound final plan can be adopted. It will also be necessary to assess the effect of possible mining of existing claims in the area before continuing rehabilitation work. Interim measures, to include regular cleaning of the sediment traps if feasible, aerial seeding, planting and monitoring, shall continue until a final approach is defined.

Cal-Idaho Gloryhole

The Cal-Idaho gloryhole is located in Sec 28, T 29N, R 8E, on private ground surrounded by the Elk City Ranger District. Like many other gloryholes in the area, it was mined in the 1930s and 1940s; water for the original operation was brought from the Kirks Fork of the American River in a thirteen-kilometer ditch (Reed, 1934). The site is now approximately five hectares (13 acres), and contains bare slopes, vertical banks, gullies, springs, mudslides and partially-revegetated slopes (Figure 39). The soils are an alluvial deposit consisting mostly of a clayey-silt, intermixed with layers of gravel, clay, silt and some sand. The upper portion of the pit is much as the miners left it at a slope of some 100 percent (Figure 40). A local sawmill dumped mill waste down the slopes for several years in the early 1980s. The mill waste, composed of bark, dirt, rock and logs, is not highly erodible, and is generally staying in place. However, the material does not appear to be encouraging vegetative growth. Springs at the southwest corner of the gloryhole continually cause mudslides in that area.

Figure 40. Upper slopes of the Cal-Idaho Gloryhole, 1988.

Annual precipitation is estimated to be 89 cm (36 inches) a year, The R1/R4 Sediment model and the Soil Conservation Service's Universal Soil Loss Equation estimate that between 161 and 234 tons of sediment are lost from the gloryhole annually (Gerhardt, unpublished). Runoff from the Cal-Idaho gloryhole, which enters Red River through a culvert under County Road 222, was very clearly sediment laden during storm events (Figures 41 and 42). The reddish silts contained in the runoff colored Red River, and the South Fork Clearwater River, up to 16 km downstream of the culvert.

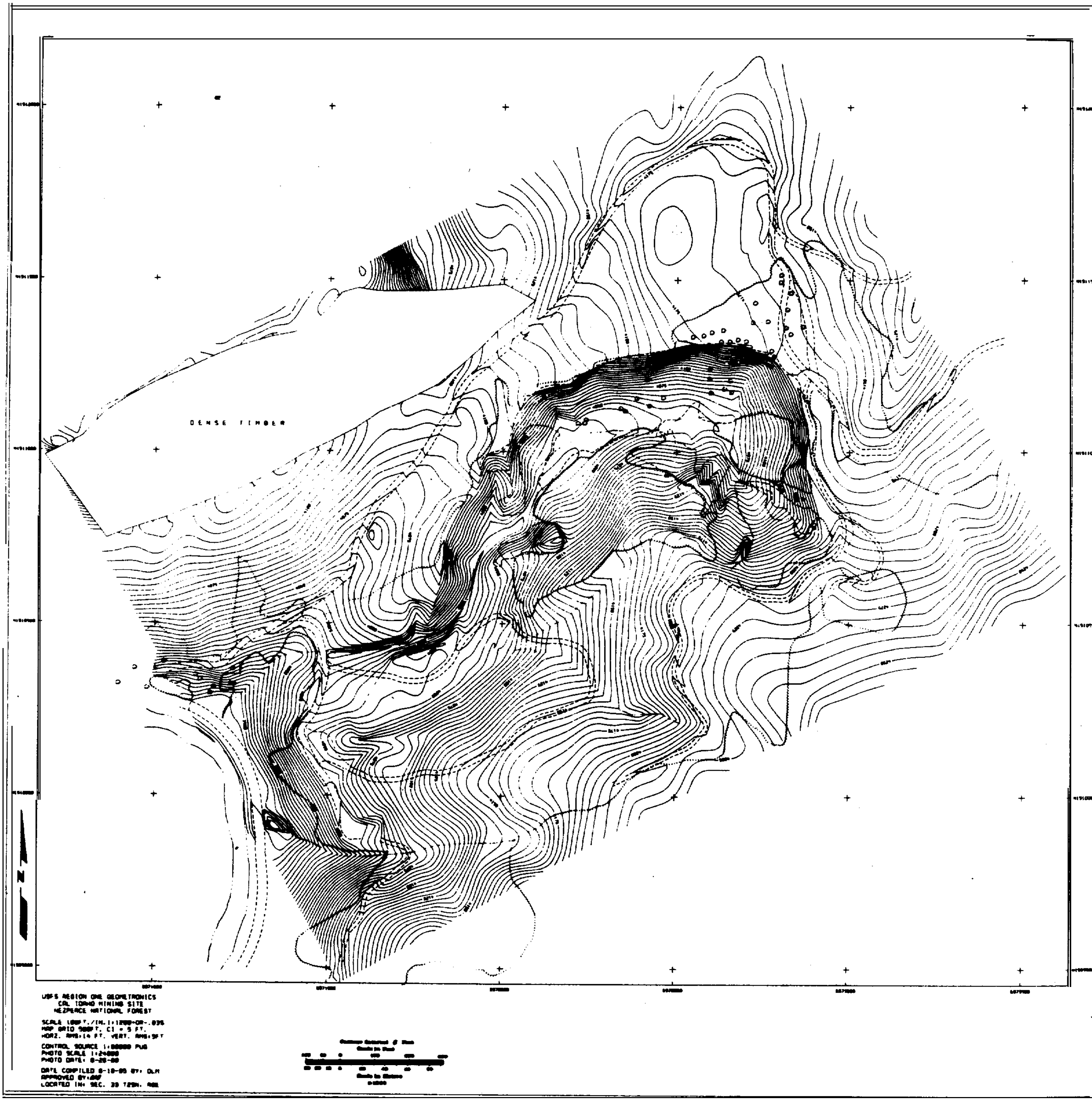


Figure 39. Cal-Idaho Gloryhole, 1980.

Figure 41. Culvert under County Road 222 draining sediment-laden runoff from Cal-Idaho Gloryhole. 1987.

Figure 42. Culvert emptying sediment-laden runoff from the Cal-Idaho Glotyhole into Red River, 1987. The distinct line in the center of the picture is where the muddy runoff meets the clear water in Red River.

The project goal was to improve fish habitat by reducing sediment input to Red River from the gloryhole drainage. Specific objectives included 1) preventing 80 to 90 percent of sediments smaller than one-quarter inch from reaching the river; and 2) trapping the sediments in such a way as to allow for their periodic removal from the collection site. L.C. Hanson Company, of Helena, Montana, was contracted to provide design proposals to meet these objectives

L.C. Hanson Company estimated both a mean annual runoff for the Cal-Idaho basin, and a peak flow amount for 2. 5, 10, 2.5, 50 and 100 year intervals. Annual runoff was calculated by using data from two USGS gaging stations which showed that the annual flow from the Cal-Idaho basin would be about .1 cfs. Three methods for calculating peak flow were compared, one of which was chosen for design use. This method indicated that a 2 year peak flow would be 1.6 cfs, that a 10 year peak flow would be 8.3 cfs, and that a 100 year peak flow would be 21.4 cfs.

Figure 43. An aerial view of the Cal-Idaho Gloryhole.
A. Site of upper sediment trap (not constructed).
B. Site of lower sediment trap (not constructed).
C. Site of rock crib check dam constructed in 1990.
Photo courtesy of L.C. Hanson Company.

LC. Hanson Company's original design called for two sediment traps, one in the basin formed by a jeep trail just below the gloryhole, and a second in the basin formed by County Road 222, where runoff from the gloryhole is directed through a culvert (sites A and B, Figure 43). The upper trap would filter 80 percent of the runoff from the basin, and would have a storage capacity of 620 cubic meters. The lower trap would have a capacity of 987 cubic meters. These two traps, according to LC. Hanson, would provide three and a half years of storage, assuming a high sediment delivery of 356 tons a year (higher than the high estimate made by the Nez Perce Forest hydrologist), and a .78 tons/cubic meter conversion factor.

USFS specialists judged that the upper of these two traps would be very costly to build, and very difficult to clean. A categorical exclusion was prepared, and other plans made for installation of the lower trap alone.

Unfortunately, objections from the landowner precluded the construction of this lower trap. The contract with L.C. Hanson was then revised to include design of a third sediment trap, a rock crib check dam, higher in the drainage than the first two (site C, Figure 43). This trap was to be constructed with treated timber and filled with dredge rock. Design plans for this structure are detailed in Figure 44. The landowner allowed construction of this third trap during the summer of 1990.

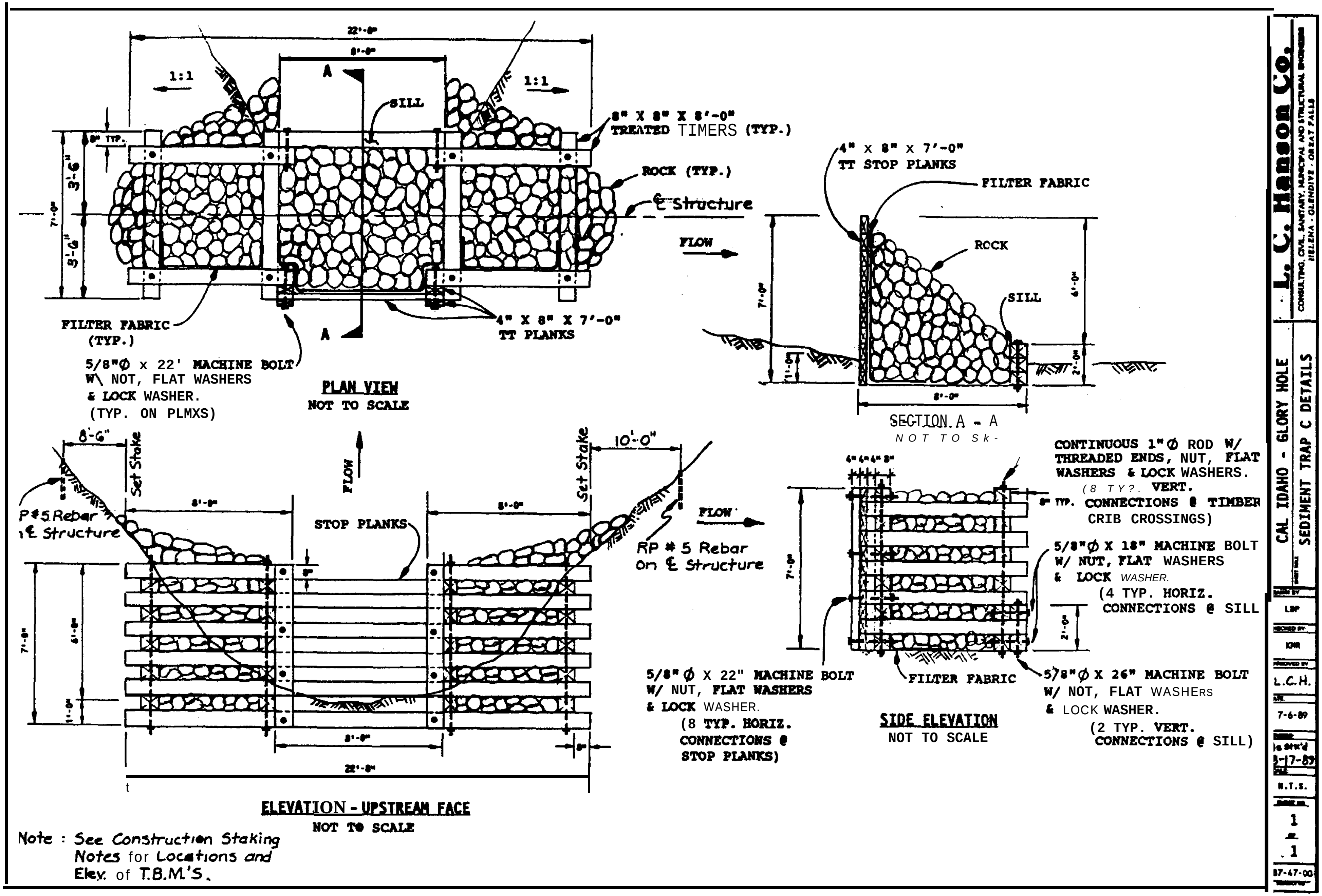


Figure 44. Contractor design of rock crib check dam constructed in Cal-Idaho Gloryhole, 1990.

First, two small check dams (designed by USFS specialists) were built prior to construction of the rock crib check dam. The first was located about fifteen meters above the construction site, and was designed to collect and divert runoff to keep the construction site dry. The runoff was funneled through a buried 4-inch pipe which drained back into the channel well below the construction site. (The pipe was capped upon completion of the trap.) The second check dam was built at the landowner's request about 91 meters above the construction site. It was full within a year, and is roughly estimated to be currently holding 153 cubic meters of sediment (Leidenfrost, pers. comm.).

The sediment trap itself was built in the small canyon which drains the majority of the gloryhole. Because of the site's inaccessibility to machinery, all work was completed with hand labor (Figure 45). A crew averaging six members constructed the trap in roughly ten days, Once the crib framework was in place, a backhoe moved rocks from some minings tailings near the site to an area where the rocks could be hand loaded onto a conveyer belt. The conveyor belt, in conjunction with a wooden chute, helped to transport the rocks down into the cribs (Figure 46).

Figure 45. Constructing the rock-crib check dam in Cal-Idaho Gloryhole. 1990.

At the time of construction, two deviations from L.C. Hanson's plans (Figure 44) were made. While runoff is meant to filter through the dam walls, it was felt that two pipes through the center of the structure would help relieve pressure from water during times of high runoff (necessary until the structure settled) (Figure 46). As sediment levels approach them, the pipes will be capped to prevent sediment from passing directly through them. Second, because it appeared that water might flow around the edge of the structure, **a** 'wing' was constructed off one side and buried in the bank.

Areas disturbed by the 1990 construction were thoroughly seeded, fertilized and mulched, both with erosion control matting and straw. Matting placed on the steep sides of the draw adjacent to the structure is holding soil well, and grass is becoming established on it.

Figure 46. Partially completed rock-crib check dam at Cal-Idaho Glotyhole. 1990. Note drainage pipe in center of structure.

Early in 1991, two small leaks were noticed underneath and to one side of the the structure. In June, crews dug out several feet of fill adjacent to the structure **and** relined the area with a combination of filter cloth, bentonite clay, and clay from the site. In addition, crews added a wing to the side lacking one, and buried it into the bank.

The sediment trap was designed to contain 308 cubic meters of sediment, but is unfortunately **located in** a position which makes it almost impossible to clean. It is hoped that the success of this structure will convince the landowner to allow the construction of the trap at County Road 222. The lower trap, because it could be cleaned, would be of far more benefit in the long run than the trap constructed in 1990.

To date, there are about 40 cm of sediment in the pond behind the structure, which roughly translates to 32 cubic meters. By adding to this figure the 153 cubic meters behind the check dam, it can be assumed that at least 185 cubic meters of sediment were prevented from entering Red River by the 1990-1991 project work. Sediments in the runoff from the basin during 1991 storm events were, in fact, discernibly reduced. While the water was still cloudy, it did not color the whole of Red River as it used to.

Leggett Placer

Leggett Placer is located in T **29N, R 7E, Sec** 19 and 20, hear Leggett Creek (Figure 2). it is very roughly estimated to be 9 hectares (22 acres) in size, and is situated in Forest Service ownership. The pit is convoluted in shape (Figure **47),** as opposed to being in a relatively simple basin configuration like the **Haysfork** and Cal-Idaho Gloryholes. Because of its configuration, the proportion of steep slope faces to the amount of material originally removed from this **gloryhole** is much higher than normal. Aider **and** lodgepole pine grow in 50 percent or so of the pit, but steep sidewalls are bare and eroding.

Between 1904 and 1912,930 ounces of gold and 128 ounces of silver were produced from **approximately** 497,250 cubic meters of gravel (Reed, 1934). Tailings were diverted directly into Leggett Creek. According to Reed, a considerable amount of the high gravel remains unworked because it lay above the ditch level. Both white and Chinese miners evidently worked in the **gloryhole** (Ibid.).

USFS initiated two projects in Leggett Placer: planting of shrubs and trees in 1987, and construction of a sediment trap on the creek draining the gloryhole in 1988. Both projects utilized funding provided by BPA, as a part of Project 84-5.

Some 3,000 red osier dogwood and mountain aider were packed into the site on four stock animals in November of 1987. One hundred and twenty of the shrubs were planted in 2.4 X 3 meter (8 X 10 foot) test plots on two-foot centers. Two of the plots contained aider, and two, dogwood. The plots were located in sites **representative** of different conditions in the gioryhoie. One was located to assess aider success on steep, dry slopes with no shade and no existing vegetation, A second was established to assess aider success on lower, less steep, more shaded areas, A third plot was designed to show dogwood **success** high in draws with steep gradients and **little** shade, and a fourth was meant to assess survival of dogwood plantings in lower gradient areas with established vegetation and shade. The remaining 2,880 shrubs were planted in locations in the gloryhole no higher than the highest point in any of the four test plots. in general, aider were planted on steeper, drier and more open slopes than the dogwood, which was planted in moister, more shaded draws.

Unfortunately, there is no current record of success rates in these test plots, although it would **not** be impossible to locate the plots in 1992, and assess **5-year** survival. Evidently, the success rate was not high, and it was **felt** that further planting would be relatively ineffective (Mitchell, **pers. comm.).**

In 1988, BPA funding was used to divert runoff from Leggett Placer through an existing pond adjacent **to** Leggett Creek (and Forest Road 849). The pond was somewhat enlarged during this initial construction, and two outlet culverts were installed. One was to handle normal flows, and the second was **to** Serve as a backup in case of high flows. in 1990, the pond was enlarged a second time, but unchanged in design.

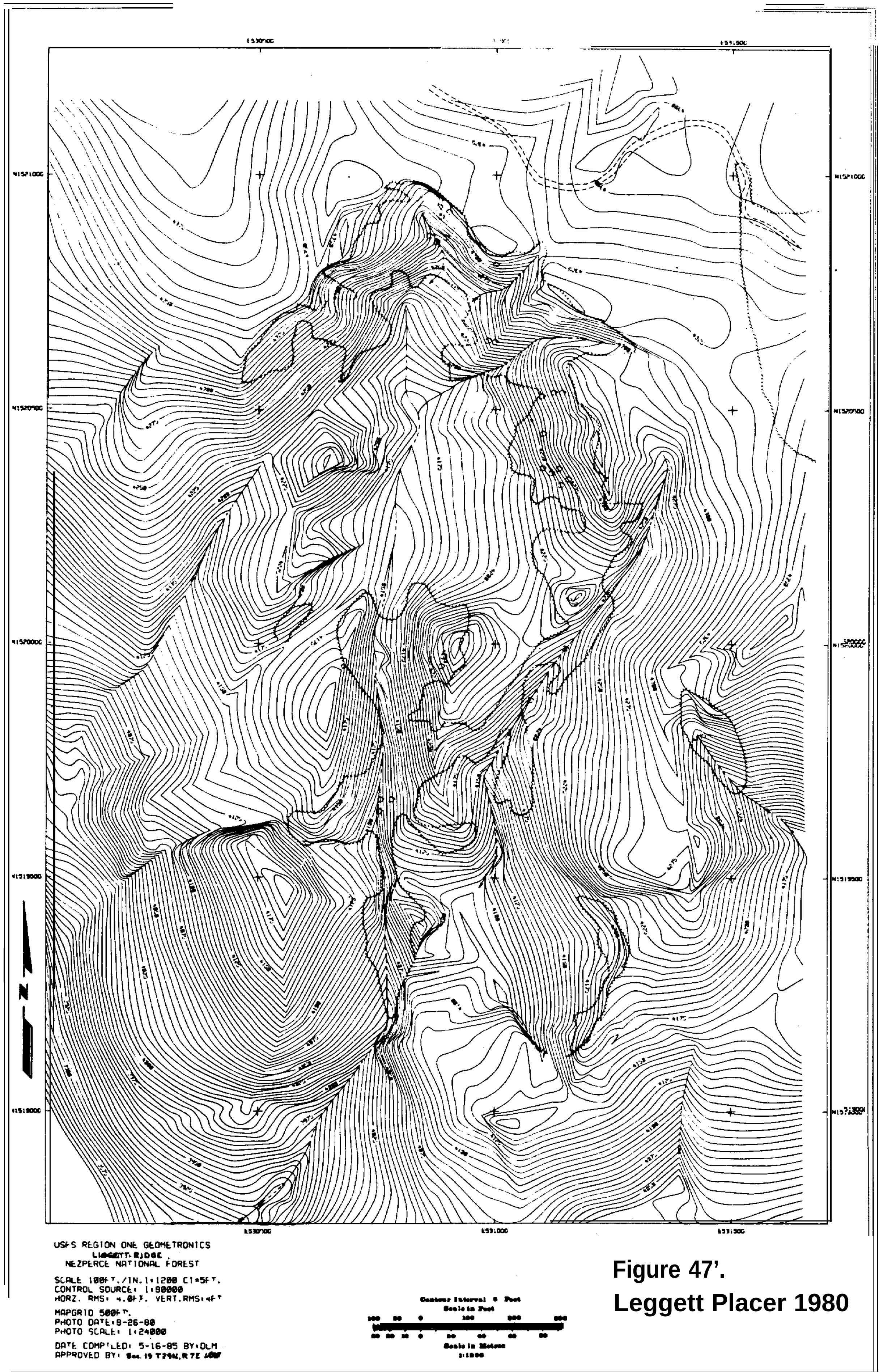


Figure 47'.
Leggett Placer 1980

The Leggett sediment trap is easily accessible to machinery after spring snow melt. USFS funds are used to empty the trap about three times a year: 73 cubic meters of sediment were removed in 1990, and 69 cubic meters in 1991. Each spring, however, the trap fills before the snow melts to allow access. During this time, runoff overflows the trap and directly enters Leggett Creek. In major storm events, too, the overflow culvert allows highly sedimented water to flow directly into the creek. Furthermore, because of site and design limitations, the trap is estimated to be only 50 percent efficient when functioning correctly (Leidenfrost, pers. comm.). The trap's location would make it very difficult to improve, but no other suitable locations exist in the area. Clearly, a tremendous amount of sediment enters Leggett Creek despite the sediment trap.

Because of its complex configuration, and its relative area of sheer headwalls, Leggett Placer presents a significant rehabilitation project. Cursory investigation indicates that Leggett Placer may not be as intrinsically unstable as Haysfork and Cal-Idaho, but bare slopes will undoubtedly be difficult to revegetate. Lessons learned in the ongoing rehabilitation of Haysfork will be of great value in tackling Leggett Placer. First, there will need to be intense examination of existing slope stability, soil characteristics, drainage and vegetative patterns to assess the potential costs vs the benefits of disturbing the site. The location and design of the existing sediment trap will also have to be analyzed.

Fisher Placer

Fisher Placer is located on private land in T 29N, R 4E, Sec 25, surrounded by the Clearwater District of the Nez Perce National Forest. The site is about 60 meters above the South Fork Clearwater River, and runoff from the gloryhole directly enters the river. The site is approximately 1.5 hectare (4 acres), and contains a main basin bordered by 80 percent slopes, several springs, and a central creek which drains the area.

The placer was reportedly opened by a man named Fisher in the 1890s, and was last worked in 1918 (Reed, 1934). Water for the operation was brought from Meadow Creek in a four-mile flume which created a fall of more than 400 feet, and supplied pressure to two 6-inch "giants" (nozzles). Sampling in 1918 showed that gravels in the west side of the pit averaged 18 cents of gold to the yard (Ibid.). Since mining activity ceased in 1918, the area has been essentially undisturbed, and in some places, there has been substantial revegetation. However, large areas on the steep slopes forming the north and west sides of the gloryhole have not supported new growth, and heavy soil movement continues to occur.

A small, marshy area with some standing water lies approximately 45 feet from the upper edge of the western face of the basin, and drains into the basin via a four-meter-deep gully. The most intense erosive activity appears to be occurring along this west face, or head, of the basin. However, sheet erosion, gullying, rilling and slumping occur throughout the placer.

Soils in Fisher Placer are Eutric glossoboralfs, the upper layer of which is typically a dark brown silt-loam. Subsurface layers may be dark brown to yellowish brown and contain cobble and gravel. Eutric glossoboralfs usually have an illuvial clay horizon which can be highly erosive in the event of a perched water table. Soil composition of a similar landslide area in the Nez Perce National Forest has been identified as 48 percent sand (range 24 to 72 percent), 36 percent silt (range 26 to 53 percent) and 16 percent clay (range 2 to 23 percent). Subsoil rock fragments account for approximately 25 percent of soil volume on the Fisher Placer site (Green, pers. comm.).

Dominant vegetation in the gloryhole includes ponderosa pine, Douglas-fir, snowberry, wild rose (Rosa spp.), gooseberry (<u>Ribes</u> spp.), and elderberry (<u>Amelanchier</u> spp). Riparian plant species include alder, cottonwood and sedges (<u>Carex</u> spp.). Thistles are present.

Between 1982 and 1987, the steep slopes surrounding the basin were seeded with a mixture which included grasses and clover. In some areas the seeding has been successful, while in the most actively eroding areas very little vegetation has taken hold.

In April, 1988, BPA funding was used to plant 470 alder and 470 red osier dogwood on the slopes of the main glory hole. In addition, two test plots were established to determine planting success. Each test plot is 4.6 X 5.5 meter (15 X 18 foot), and originally contained 15 alder and 15 dogwood on three foot centers. The two species were alternated, so that each plant was surrounded by plants of the second species. One plot is located on a southern aspect of a slope to the north of the main gloryhole, while the other is located on a western face at the head of the basin. The plots are on similar gradients, and soil types appear to be identical.

In August, 1988, the test plots were read and a 3.5 month survival rate determined. In plot **#1,** the less shaded of the two plots, 48 percent (10) of the alders were living, 52 percent (11) of the alders were dead; 71 percent (15) of the dogwood were living, 29 percent (6) were dead. In plot **#2,** 81 percent (17) of the alders were living, 19 percent (4) were missing; 86 percent (18) of the dogwood were living, 14 percent (3) were missing. All three of the missing dogwood, and three of the four missing alder, had been undermined and carried off by water movement, which had created a rill(15 X **10** cm) down one 'column' of shrubs. This **rill** was not observed at the time of planting. The higher success rates in plot **#2** (100 percent of the remaining plants were living) are most likely due to a greater proportion of shade, and correspondingly higher soil moisture. It should be noted that although the 1988 summer season was an especially dry one, sheet erosion over both plots, as indeed throughout the entire placer, was significant.

As the 'pond' area beyond the western edge of the basin appears to accelerate erosive action within the site, it is recommended that this situation be more thoroughly addressed. Cursory investigation by Forest geotechnical engineers in 1988 revealed that erosion on the disturbed site could be reduced by diverting the water away from the current channel and onto a more stable drainage site. (A small gulch about 80 meters from the ponds was identified as a possible drainage site.) However, no actual plan of action has been defined, nor relevant analysis completed. (Access to the 'pond" is possible for machinery, along an old skid road to the south of the site.)

In addition, continued planting and seeding would undoubtedly contribute to the stability of the soils in the placer. It is recommended that snowberry be included in future planting efforts, as this species is establishing itself naturally in drier areas. Likewise, since ponderosa **pines** and cottonwoods have invaded the area, seedlings of these species might be successfully started. Erosion control matting would help to decrease surface erosion and promote more vigorous revegetation.

From its inception in 1983, Project 84-5 grew to include a wide array of enhancement and rehabilitation approaches and techniques. Project activity focused on several of the most significant adverse impacts to the fisheries resource in the South Fork Clearwater River system: the dredge-mined areas along Crooked River, the unstable and eroding banks in Red River, and sediment production by the gloryholes. These are highly complex problems which natural processes may have taken centuries to resolve.

Project Summary: Previous dredging in Crooked River had left the stream with a lack of habitat diversity and bank cover, and a culvert prevented migration of adult chinook and steelhead into high quality spawning and rearing habitat. Project activity in Crooked River included removal of the barrier; installation of over 660 pool and cover-creating instream structures; creation of around 15,000 square meters of juvenile rearing and winter habitat through side channel construction and pond connection: construction of approximately 9,230 square meters of flood plain: and planting of some 30,000 hardwood shrubs and small conifers in riparian areas.

Red River, both dredged and heavily grazed, also exhibited a lack of diversity and bank cover. In addition, Red River suffered from severe bank erosion. Project work in Red River included bank stabilization: construction of 319 instream structures, 1,548 meters of side channels, and 750 meters of fencing; planting of over 11,000 shrubs and trees; and intensive restoration and realignment of 460 meters of river channel.

A boulder cascade in Meadow Creek acted as a partial migration barrier to adult steelhead, and a total barrier to migrating chinook. The cascade was altered through blasting and structure construction to allow passage of both steelhead and chinook to approximately 145,660 square meters of spawning, rearing and overwintering habitat.

Finally, several historic mining sites on the Forest were identified as primary producers of fine sediment to the South Fork Clearwater system. Project work included the construction and/or maintenance of sediment traps at Haysfork, Cal-Idaho and Leggett Gloryholes, which to date has prevented approximately 1,258 cubic meters of sediment from entering the South Fork Clearwater system. Improvement of access to the Haysfork Gloryhole and vigorous revegetation efforts were also made.

Conclusions: During the decade over which Project 84-5 evolved, significant advances were made in the science of fisheries habitat enhancement. Much of what was ‘state of the art” in 1983 is not so considered today. Our conclusions are both specific to our project activity in the South Fork Clearwater system, and of a more general nature. Those in the latter group are not necessarily unique because they are in accordance with current trends in fisheries habitat restoration and enhancement.

1. Removal of tailings piles to create a natural floodplain, which will allow high flows to dissipate energy and deposit fine sediments, can be an effective means of aiding a dredge-mined stream to regain stability and healthy riparian vegetation, Rehabilitation projects in heavily dredge-mined streams must address the possibility of subsurface flow where banks are composed of unconsolidated material.

2. Enhancement projects must be designed in accordance with hydraulic and geomorphic principles specific to the stream in which the project is to occur. Structure effect, as well as other enhancement activity, will benefit from specific definition of appropriate locations and elevations for bankfull stage,

the floodplain, and valley terraces above the floodplain. Project activity is more likely to result in long term success where emphasis has been placed on restoring natural channel pattern.

3. In Red and Crooked Rivers, pool creating structures which increased width:depth ratios resulted in sediment deposition and channel widening. In Red River, which transports high levels of sediment, any reduction in the stream's ability to transport sediment is especially undesirable. Structures that decreased the width:depth ratios, like pinch weirs, downstream V weirs and wing deflectors, provided quality pool cover while allowing sediment transport in accordance with the streams' natural processes of recovery.

4. Assessment of the Haysfork Gloryhole by USFS specialists and a contracted landscape engineering company helped to identify the tremendous scale of sound rehabilitation efforts, It also re-illustrated that rehabilitation efforts of this magnitude must include the increased perspective supplied by a wide range of specialists, including engineers, hydrologists, soil scientists and minerals reclamation specialists. This better understanding of what gloryhole rehabilitation involves will be invaluable in future planning processes.

5. Barrier removal continues to be an effective method of fisheries enhancement, provided there is careful analysis of the effect of the barrier removal on resident fish populations.

6. Course cobble tailings in Crooked River, browsing and competition from native grasses in Red River, and soil movement in the gloryholes made revegetation a difficult process. In general, revegetation efforts should focus on the re-establishment of native vegetation. In most cases, native vegetation survived in greater numbers; in one case non-native vegetation (reed canarygrass) became so predominate as to inhibit revegetation by native species which would have provided greater long-term benefit.

7. Although it may be insignificant in comparison to the annual volume produced by continuously eroding banks, sediment production during installation of instream and bank stabilization structures is highly visible. In some cases, people who observe this short-term effect are themselves under regulation for compliance with water quality standards, and therefore sensitive to increases in turbidity. Because of its visual impact, in-stream construction should be accompanied by a well-developed public education effort to familiarize the public with project benefits.

8. The necessity of maintaining a "watershed perspective" in fisheries habitat management is becoming more widely recognized. We now acknowledge the need for interdisciplinary coordination before commencement of enhancement work. An examination of the watershed soil and land types, management history, vegetational regime and hydrologic character is vital to accurately identify limiting factors and the means to address them. The success of individual elements of our project work was directly related to our recognition of the importance of the interdisciplinary approach.

9. Long range planning is essential to provide for appropriate monitoring of project results. Monitoring must be an issue of primary emphasis before, during and after the project to be effective. In a project spanning a decade, like this one, ongoing monitoring can help identify both successes and failures in a timely manner. Although we were not funded to monitor the results of this project work, we hope

that future enhancement efforts will involve a greater emphasis on pre-project inventory work, a during-project "feedback loop' and after-project analysis.

10. As the years pass since the first fisheries habitat enhancement work, it is becoming increasingly evident that long range planning for maintenance of project sites is vital. Specialists must recognize that many enhancement efforts, especially instream structures, will require maintenance as the stream channels evolve in their natural cycles. Sediment traps, too, will have to be emptied and repaired. Project work on private land is of particular concern to us, because the Forest Service is prohibited from funding projects on any but Forest lands except in unusual circumstances. The existing BPA/USFS agreement, however, makes no provision for funding of future maintenance.

11. Finally, the increasing recognition of the need for interagency coordination is especially applicable in projects of this magnitude. Our inability to obtain easements from private landowners, for instance, was the primary obstacle we faced in Red River. The Soil Conservation Service, the U.S. Fish and Wildlife Service and the Idaho Department of Fish and Game currently handle wetlands reserve and improvement programs which may have assisted implementation of our habitat enhancement objectives on private land. Interagency cooperation may well be the key to future project work in Red River and other watersheds of mixed ownership.

Recommendations:

1. Maintain existing work as necessary. Obtain long term commitment and funding with which to repair instream structures and empty sediment traps. Not only will future maintenance be vital to ensure their continued benefit, it will be necessary to prevent the structures and sediment traps from themselves becoming erosional hazards.

2. Analyze the existing check dams in the Haysfork Gloryhole and decide upon a course of action sufficient to prevent the thousands of cubic meters of sediment stored behind them from entering Newsome Creek. Settle the issue of existing mining claims at Haysfork to ensure long term protection of any rehabilitation work.

3. Establish the necessary interagency cooperation and legal easements to continue fencing, channel restoration and bank stabilization on private segments of Red River.

4. Continue removal of tailings piles and corresponding creation of flood plain along Crooked River. This has the additional benefii of supplying material with which to surface forest roads, but must be conducted in accordance with the historical value of the site.

5. Continue gloryhole reclamation efforts with coordinated interagency involvement, weighing carefully the pros and cons of mechanical disturbance and sediment traps, while recognizing the historical value of the sites.

6. Assess watershed rehabilitation and improvement opportunities in the Meadow Creek drainage to complement the success of the barrier removal and corresponding newly available chinook and steelhead habitat.

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Red River Reconstruction Project

Red River Ranch

1991

Project Description and Base Monitoring Data

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Elk City, Idaho

April 1992

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The Kelly Creek Flycasters of Lewiston gave us their support throughout the project, facilitating both a $2000 grant from the Idaho Dept. of Fish and Game, and the cooperation of Potlach Corporation's nursery, which is growing Red River lodgepole pine seedlings to sapling size. The Flycasters will plant the trees at the project site this spring. We also wish to acknowledge the supplemental financial support received from the US Fish and Wildlife Service's Habitat Improvement Program and from the Idaho Dept of Fish and Game.

We gratefully acknowledge the support and encouragement we received from Nick Gerhardt, Nez Perce Forest Hydrologist. Without it, this project would not have progressed past the wishful-thinking stage. Dave Rosgen and Rusty McKee both supplied advice and encouragement, and their willingness to assist rank beginners with a complex project is much appreciated, especially now, in hindsight. Jeff Adams sheltered us from several unforeseen administrative crises, and enabled us to concentrate on the on-the-ground work. Our thanks also to Kent Gilmore for planning assistance and crisis intervention on a moment's notice. R.A. Holzer and his Green Machine did an outstanding job on the apres-construction clean-up, and the planting and sodding work. About our friend, Brooks Beegle's, many contributions to this project, suffice it to say that he took diligent care of the routine chores that kept things running, constructed the headgate structures from a lo-minute sketch done by Dave on the hood of a truck, and was there to effectively minimize the impact of the several crises that occurred, We could not have had a more reliable back-up person. He was calm in the midst of pandemonium and his presence helped us through a number of wrenching moments.

We especially wish to thank Mrs. Edith Mullins, owner of Red River Ranch, and her family for their interest in and enthusiasm for our vision of a river restored to near-natural conditions and protected from stock grazing. We are very grateful for their continued strong support throughout the construction phase, when the reality of heavy equipment and diversion berms in the river must have come as something of a shock.

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Introduction

This report describes the Red River Ranch project, which was undertaken in 1991 to restore a dredge-mined, straightened segment of Red River to a stable geometry that should maintain high-quality, diverse habitat for anadromous and resident fish. The report's primary objectives are to briefly describe the planning, materials acquisition and construction phases of the project and to document the pre- and post-construction river geometries and pre-project fish habitat condition. The monitoring plan - as yet unfunded - is also outlined.

The 1991 project was funded by the Bonneville Power Administration, the US Forest Service, US Fish and Wildlife Service, and the Idaho Dept. of Fish and Game. It is located on land owned by Mrs. Edith Mullins, known as Red River Ranch. Substantial material assistance was provided by the Shearer Lumber Company's Elk City mill, the Kelly Creek Flycasters of Lewiston, and the Idaho National Guard. Potlach Corp. also cooperated in the project.

Background and Context

The "Mullins" project was part of the BPA-USFS cooperative South Fork Clear-water River Habitat Enhancement Project, which was initiated in 1984 to improve spawning and rearing habitat for spring chinook salmon and summer steelhead. Fish habitat in the upper South Fork Clearwater basin had been seriously degraded by a variety of land and river uses occurring over the past century, most notably dredge mining and hydraulic placering, stock grazing, road construction and timber harvest. The anadromous fishery in the Upper South Fork Clearwater basin was completely extirpated after a dam on the South Fork blocked upstream migration in 1911. In accordance with the removal of the dam in 1963, the Idaho Dept of Fish and Game began a reintroduction program for anadromous salmonids, and the objective of the BPA-USFS cooperative agreement was to support this effort by restoring degraded habitat and stabilizing some of the most important sediment sources in the watershed.

Red River is a tributary of the South Fork Clearwater River, and the one in which reestablishment of naturally reproducing populations of chinook has most nearly approached accomplishment. In 8 of the last 18 years, Red River has had the highest number of chinook redds in the entire Clearwater River system. Nevertheless, habitat in Red River is thought to be severely degraded, principally because excessive sedimentation and cobble embeddedness drastically reduce the rearing space and overwintering success for juvenile salmonids (Hillman, 1986).

In the upper one-half to two-thirds of its basin, Red River flows alternately through steeper, narrower valley sections (mostly National Forest land) and wide meadows, which are mostly privately owned and are used as hayland and/or pasture for horses, mules and cattle. Downstream of the Ranger Station (see location map, Figure 1) parts of the river, including the Red River Ranch section, were dredge-mined and channelized in the 1940s and 1950s. Typically, the lowered base level in the dredged reaches appears to have caused bed degradation upstream of those reaches. Likewise, the abrupt change in roughness at the downstream end of the straightened reaches, where the natural meander begins, induces sediment deposition on bars and accelerated retreat of the opposite banks. As a result, extensive areas of the lower river are subject to rapid erosion of banks up to 6 feet in height. The problem is exacerbated by stock and wildlife grazing. What riparian shrubs remain are heavily browsed and root strength is inadequate to

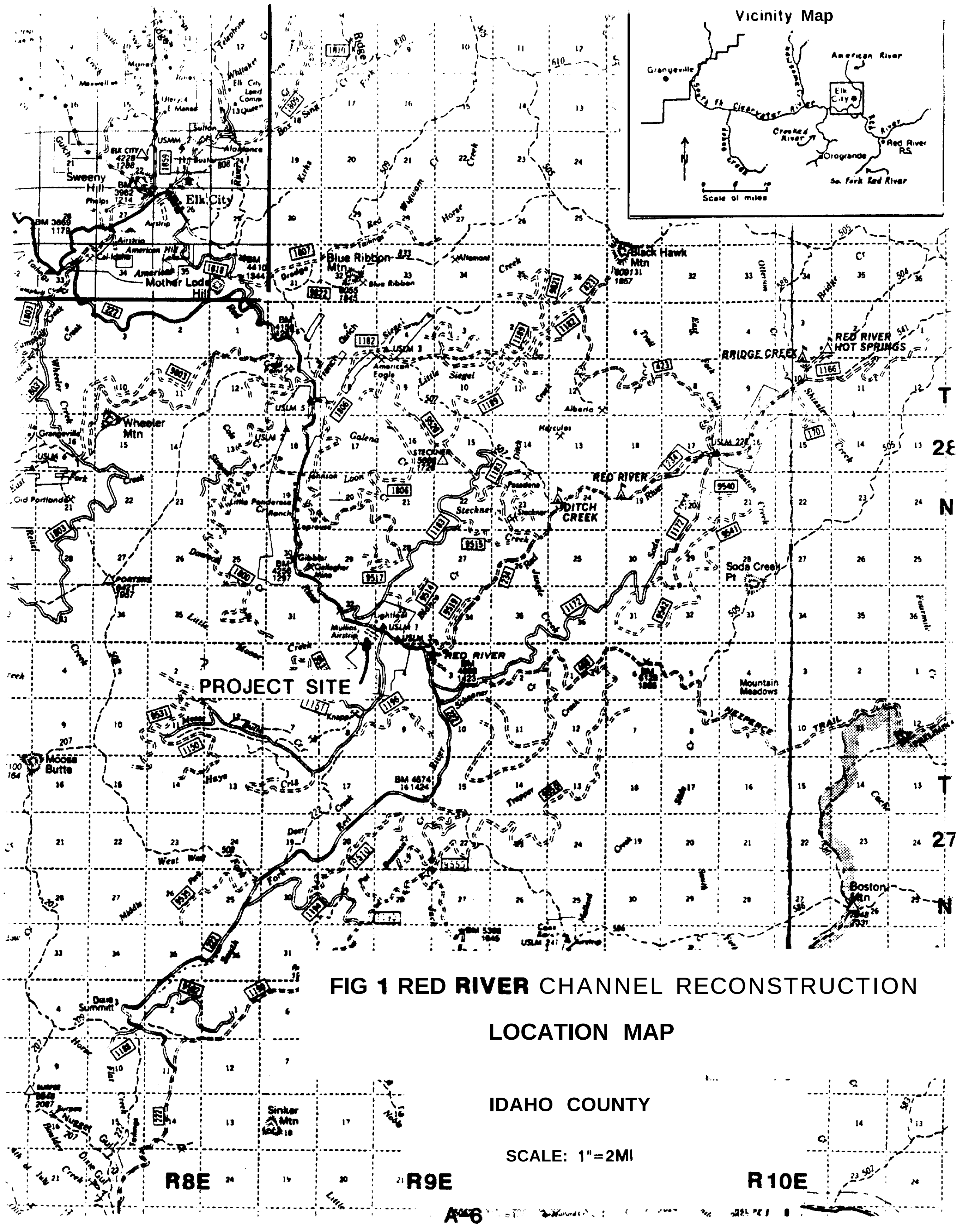


FIG 1 RED RIVER CHANNEL RECONSTRUCTION

LOCATION MAP

IDAHO COUNTY

SCALE: 1"=2MI

sustain stable undercut or vertical banks. The 1987 Nez Perce National Forest Plan estimated this lower section of the river to be at 50% of natural fish habitat potential, due primarily to the lack of habitat diversity caused by mining. The Plan stated that direct habitat improvements would be scheduled to replace the lost pool-creating structural components. Habitat improvements such as riparian planting, structural bank stabilization and riparian fencing had been accomplished on National Forest lands, but long-term maintenance questions impeded work on private lands. The Mullins project was intended to demonstrate to other private landowners how channel and riparian area restoration could benefii not only fish habitat and recreational fishing, but also improve the area's potential for waterfowl and other wildlife as well as its aesthetic values.

Problem Description

Channel Stabllity: About 1/4 mile of the downstream part of the valley at Red River Ranch was dredge-mined in the 1940s, and at least two meander bends were cut off by that operation. The landowner reshaped the dredge piles and successfully promoted re-establishment of lodgepole pine in the stream-side area. Since 1949, the river in and upstream of the mined area has become progressively straighter, probably due primarily to the landowner's attempts to correct sedimentation and stability problems caused by mining, road construction, timber harvest and streamside clearing for pasture. As a result of these activities, the river segment downstream of the Moose Butte bridge shortened from 4454 feet in 1936 to 3448 feet in 1983 (lengths estimated from aerial photos of these dates), and the sinuosity decreased from 1.5 to 1.16. Judging by the apparent amplitude and curvature of old oxbows in the former floodplain, it seems likely that the channel was already disturbed in 1936 (the date of the oldest aerial photography), and that before European settlement it may have had an even higher sinuosity. The 1983 aerial photo of the Red River Ranch segment of Red River is shown in Figure 2.

In his 1990 report "Proposed Restoration - Red River, Idaho,' Dave Rosgen identified these specific stability problems in the Red River Ranch segment:

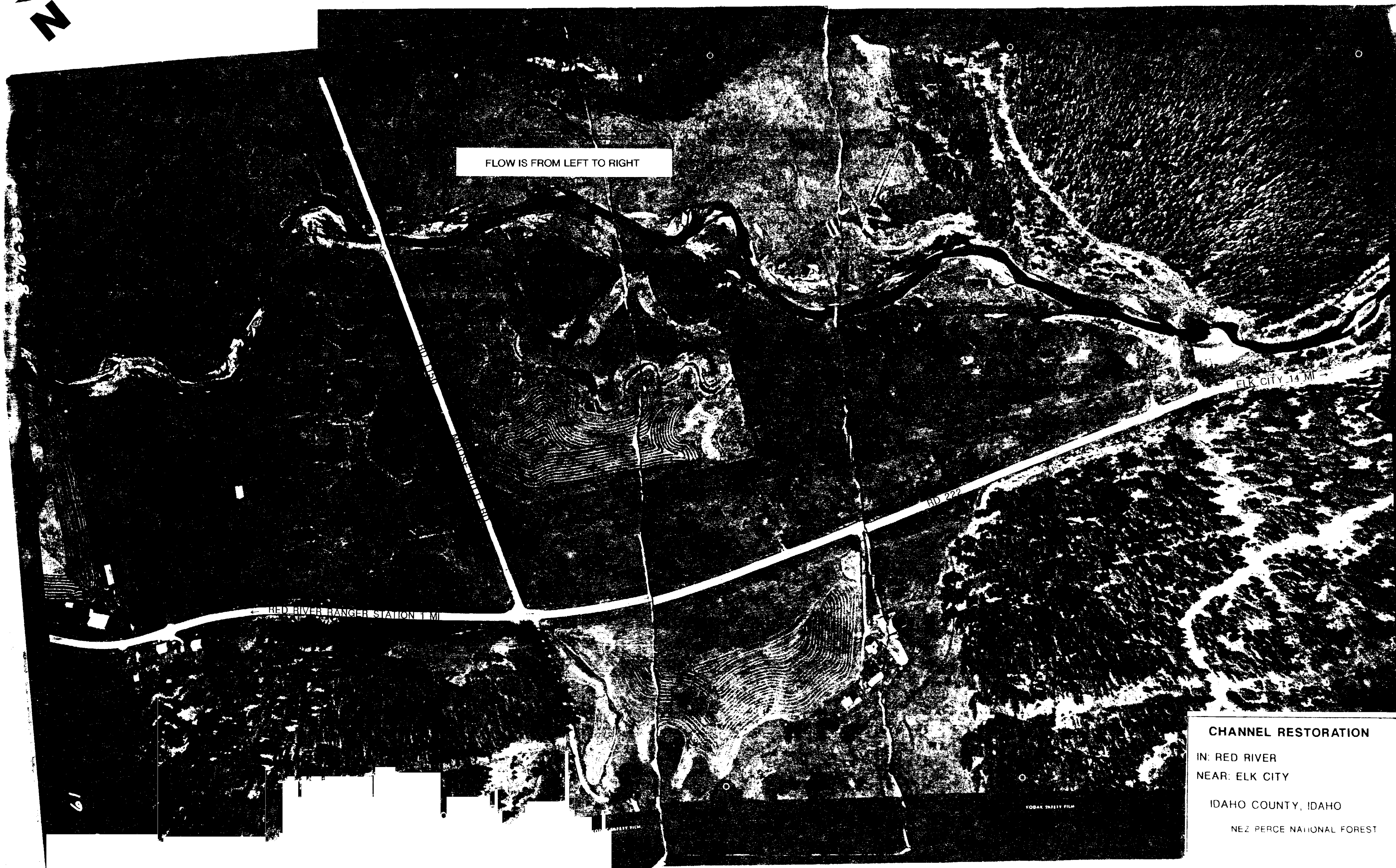
1) width-depth ratio higher than typical for a C3 channel (a C4 in Rosgen's 1991 classification system update);

2) alignment (radius of curvature, meander length and amplitude) altered beyond that required for a C3 stream type.

A sketch of the project reach is shown in Figure 3. In 1990, average width-depth ratio for 12 cross sections surveyed in a 1700-foot reach downstream of the bridge was 44 (see Table 1). Meander lengths varied between 514 feet and 1015 feet, averaging about 840 feet. By comparison, meander lengths measured from the 1936 aerial photo averaged 448 feet. Radius of curvature ranged from 86 feet to 446 feet for the 2nd, 3rd and 4th bends below the bridge. In the same report, Rosgen also stated: 'Excessive bar deposition has shifted the velocity distribution to the near bank region and the higher width/depth ratio has reduced the shear stress necessary to move the sediment load of the river. The result is an accelerated sediment deposition and lateral channel adjustment.' Streambed sediment accumulation produced the uneven longitudinal profile shown in Figure 4. The aerial photo (Figure 2) shows the transverse bars that were present in the channel. These bars forced water against the outside banks in such a way as to cause excessive bank erosion, which was conservatively estimated to produce on the order of 300 tons of

FIG 2 8/16/83 AERIAL PHOTO COMPOSITE

APPROXIMATE SCALE 1:3728



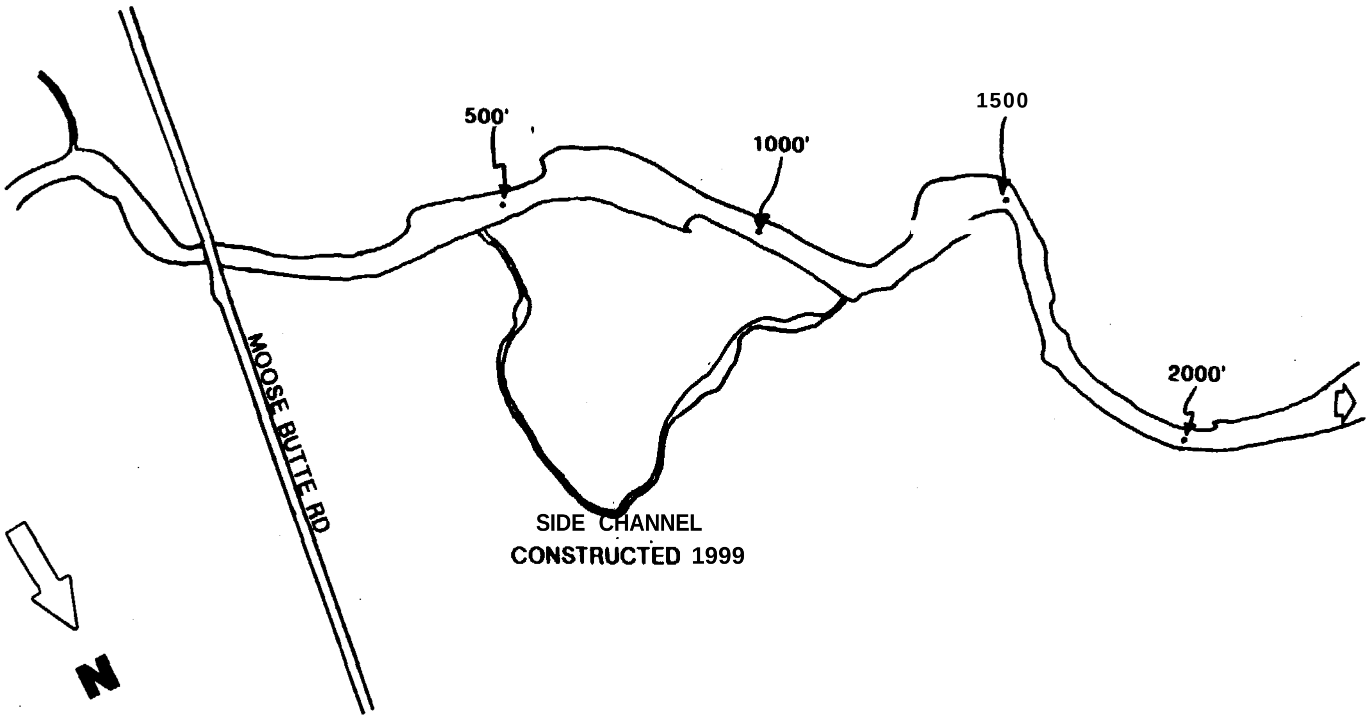


FIG 3

MSTANCES SHOWN ARE MEASURED ALONG CHANNEL FROM BRIDGE

PRE PROJECT CHANNEL PLANVIEW

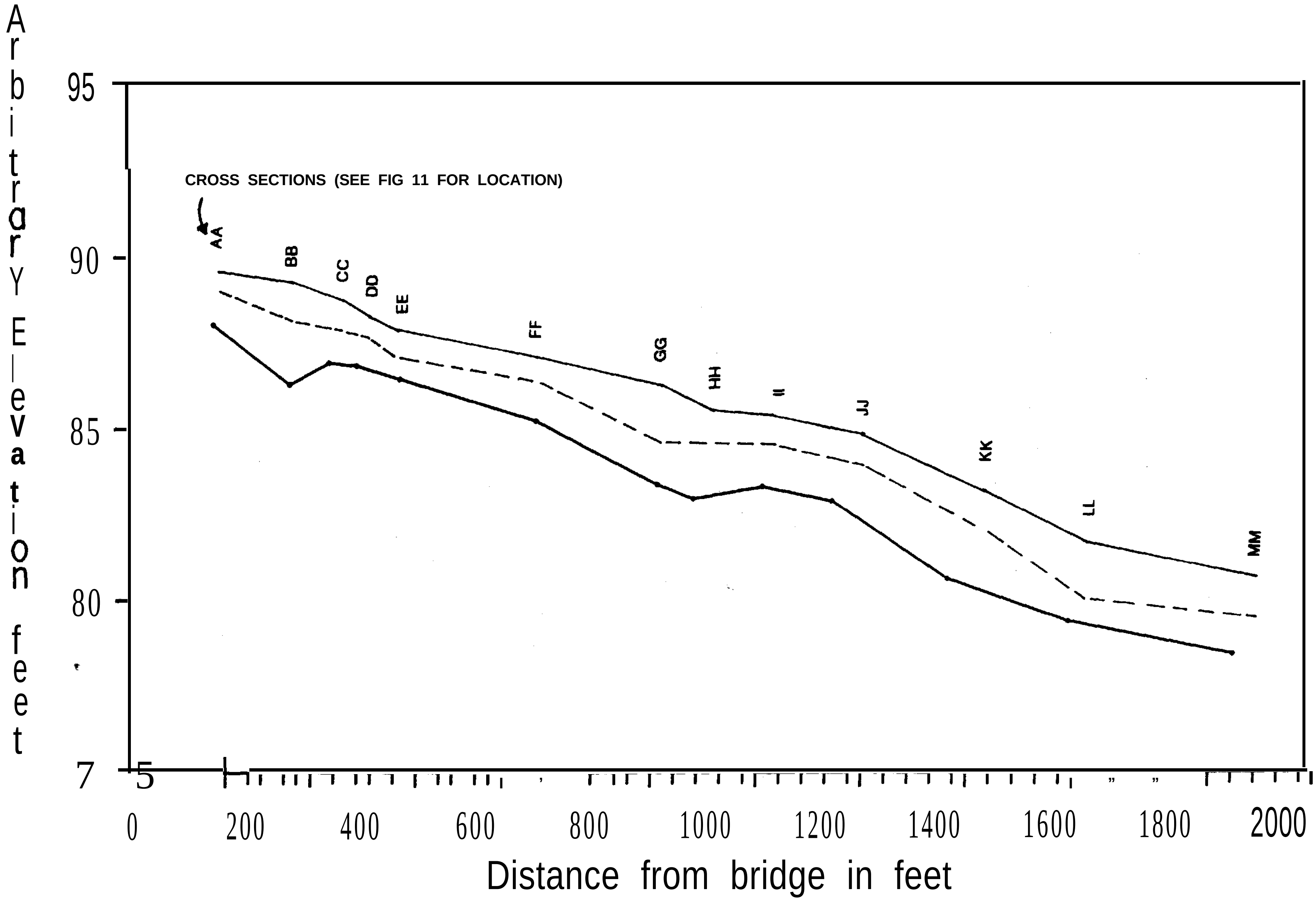
1990

RED RIVER AT RED RIVER RANCH

SCALE 1:3728

FIG 4 RED RIVER LONG PROFILE

OCTOBER 1990



sediment/year. For comparison, *natural* annual sediment yield for the watershed above the Moose Butte bridge is estimated by the Nez Perce NF at 821 t/yr.

Table 1. Mean bankfull width, depth and cross sectional area for cross sections surveyed before and after 1991 project construction.

Parameter	Statistic	‘October 1990 (n=12)	November 1991 (n=9)
Bankfull width (ft)	Mean	56	53
	Range	45-72	40-66
Bankfull depth (ft)	Mean	1.35	1.48
	Range	0.9-2.3	1.0-1.7
Width:Depth Ratio	Mean	44	3 6
	Range	25-72	24-47
Cross Section Area (ft^2)	Mean	75.5	77
	Range	51-113	56-l 03
Bankfull Maximun Depth (ft)	Mean	2.14	2.64
	Range	1.45-3.00	1.75-3.30

Fish Habitat: In 1990, stream habitat and fish density surveys were performed on Red River in the reach defined by the Red River Ranch. A more detailed summary of the the survey is included in the PROJECT MONITORING section of this report.

In general, stream habitat complexity was found to be low. The habitat was dominated by riffles separated by shallow glides; the surveyed pool:riffle ratio was 18:82. In the entire 1055 meter reach surveyed only two pools were recorded. There was little hiding cover or overwintering habitat and slow water feeding sites occurred infrequently. Cobble embeddedness was high and limited the quality of the few available spawning areas. The woody shrub component of bank vegetation has been lost due to grazing and active removal; the shallow rooted grasses which remained contributed little to bank stability or overhanging bank cover. There was only one piece in-channel woody debris and no riparian trees which could become in-channel woody debris in the future.

Project Objectives

Specific objectives for the channel and fish habitat restoration project were to:

1) reconstruct a channel planform (sinuosity, meander geometry) and cross section shape that would be in dynamic equilibrium with bankfull flows and sediment loads: ie., that would provide the capacity and competence adequate to transport supplied sediment through the reach. In such a channel, natural flow dynamics would work to maintain diverse, high quality fish habitat components (deep pools, clean riffles).

2) reduce bank erosion to near-natural rates and increase the available resting and rearing area by stabilizing and revegetating the banks. Construction of 'native material revetments'. (Rosgen, 1990) would increase the amount of overhanging bank cover and induce pool scour. The vegetation to be planted on these revetments would increase stream shading and nutrient input from litter fall.

3) further increase the area available for juvenile fish rearing and overwintering by expanding an existing side channel and constructing an off-channel pond in the floodplain.

4) provide for long-term stability of the reconstructed system by revegetating and fencing the riparian area. Revegetation would emphasize re-establishment of deep-rooted shrubs and trees to provide for bank stability and undercut maintenance as the constructed revetments age. Grasses and legumes that provide cover and forage for migrating and nesting waterfowl would also be planted.

Objectives 2-4 were achieved in 1991 or will be in 1992. Because of planning problems, the first objective was not fully accomplished. This was mitigated by placement of grade controls, and the project will be monitored to determine the effectiveness of this more artificial method of channel stabilization.

Project Design

Design channel width, depth and meander geometry were selected based on empirical relationships between these variables and bankfull discharge.

Several methods were used to estimate bankfull discharge for the Red River Ranch area (drainage area = 101 sq.miles). 1 O-year records from two USFS gaging stations on Main and South Fork Red River at the Ranger Station were fitted to Log Pearson Ill distributions and gave an estimate of 5.5 cfs/mi² for the 1.67-yr peak flow. 1.67-yr flow estimated from drainage network characteristics (per OFR 81-909) was 10.5 cfs/mi². A relationship between discharge, cross section area and slope, developed from USFS data for the state of Idaho produced an estimate of 7 cfs/mi². By comparison, the 30-yr record (1947-1976) for a gage on the South Fork Clearwater River at Elk City shows the 1.67-yr flow for that 261 mi² drainage area to be 6.7 cfs/mi². This gage was considered the best local indicator of runoff frequencies and was heavily weighted in choosing the design discharge of 760 cfs or 7.4 cfs/mi². As would be expected, this is higher than the area discharge for the larger drainage area at the South Fork Clearwater gage. It is also higher than the 10-yr local gage records would indicate, because the period of record is believed to include a predominance of lower than 'normal' runoff years.

It is interesting to note that bankfull elevations determined from channel indicators in the Red River system, when applied to the USFS hydraulic geometry equation referenced above, consistently lead to predictions on the order of 3.2 cfs/mi^2 for bankfull discharge. The estimate of 7 cfs/mi^2, noted above, was derived from channel indicators that may in fact have indicated a low terrace about 1 foot above current bankfull elevation. If bankfull stage is identified at a lower slope and vegetation break on the same cross sections, then predicted bankfull discharge is again about 3.2 cfs/mi^2. Given the data from the South Fork Clearwater gage this is hard to believe. However, if there has indeed been a medium-term decrease in annual runoff during the last 10-1 5 years, as compared with the gage period of record (1947 through 1976), channels may have narrowed in response. This is the source of confusion that led to the aforementioned planning error: ie., it is possible the reconstructed channel was designed overwide. The pre-project channel widths, depths and areas given in Table 1 are based on the lower estimate of bankfull elevations.

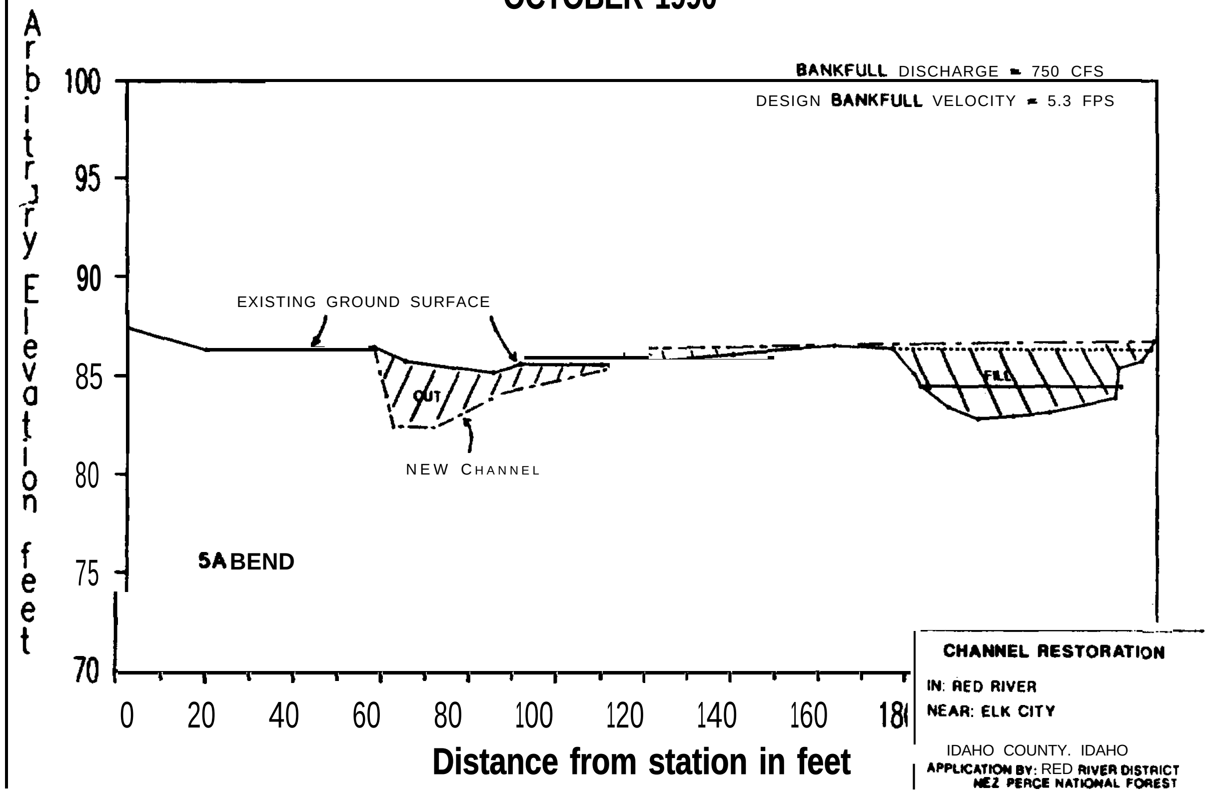
In any case, design width was determined from another USFS empirical equation, again based on data from 29 gaging stations in Idaho, relating bankfull discharge to width. Design width for a discharge of 750 cfs was 60'. Design cross sections submitted in the application for the Idaho Dept of Water Resources Stream Alteration permit and the US Army Corps 404 permit are shown in Figures 5a and 5b. Note that the trapezoidal shape for crossover reaches, shown in Fig. 5b, was adjusted to a keel shape at Dave Rosgen's recommendation such that the thalweg is defined in the channel center.

The designed meander pattern submitted with the permit application is shown in Figure 6. It was determined in part by existing floodplain features and is consistent with empirical relationships between meander length, radius of curvature and channel width. Leopold, Wolman and Miller's (1964) equation ($Lm = 10.9\ w^{1.01}$) predicts a 681 -foot meander length for a 60-foot-wide channel. Richard's (1982) equation ($Lm = 12.34w$) would produce a recommended meander length of 740 feet. Meander lengths in Figure 6 are 746 feet and 599 feet. Measured along the channel, successive crossovers between bends should be at 5 to 7 times channel width (Leopold, Wolman and Miller 1964). In this design they were at intervals of about 7 times the width. Radii of curvature for the designed bends were 3.5, 2.9 and 2.5 times channel width, consistent with the range of values observed in very large numbers of alluvial rivers (between 2 and 3 times bankfull width).

Sketches of the bank revetment structures and the vortex rock structures are shown in Figures 7 and 8. These are schematic designs (Rosgen 1990, Leopold and Rosgen 1991); Dave Rosgen has successfully used these types of structures in a number of earlier projects. The bank structures are an intricate latticework of logs, rootwads and boulders, backfilled with pitrun rock, and topped with topsoil and sod. The foundation log is set l-2 feet below thalweg elevation to accommodate expected scour in the pool. Rootwads with 12 to 15 feet of bole attached are placed on top of these footer logs, facing the flow and armoring the toe of the bank. Assuming bend curvature is 'correct, their interaction with the spiral flow pattern at the bend will maintain clean deep pools under and in front of the rootwads, providing excellent overhead cover and resting areas for adult salmonids. Interlaced logs with boulder counterweights and wedges are placed on top of the rootwads to bankfull or terrace elevation and topsoiled. As much of the structure as possible is interplanted with deep-rooted shrubs, clump-planted if possible by the excavator during construction. In the present case, shrubs were not readily available for transplanting, so the structures were intensively sprigged with willow in the spring of 1992.

RED RIVER CROSS SECTION HH

OCTOBER 1990



RED RIVER CROSS SECTION JJ

OCTOBER 1990

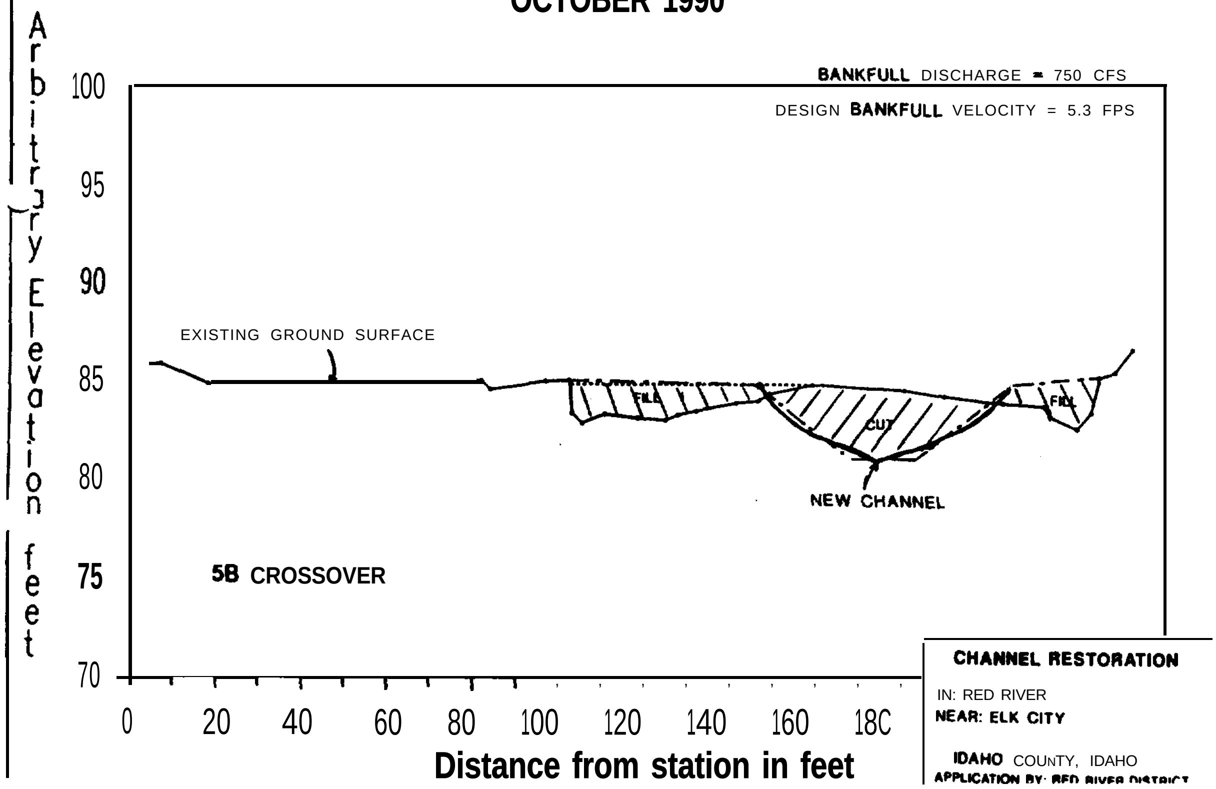
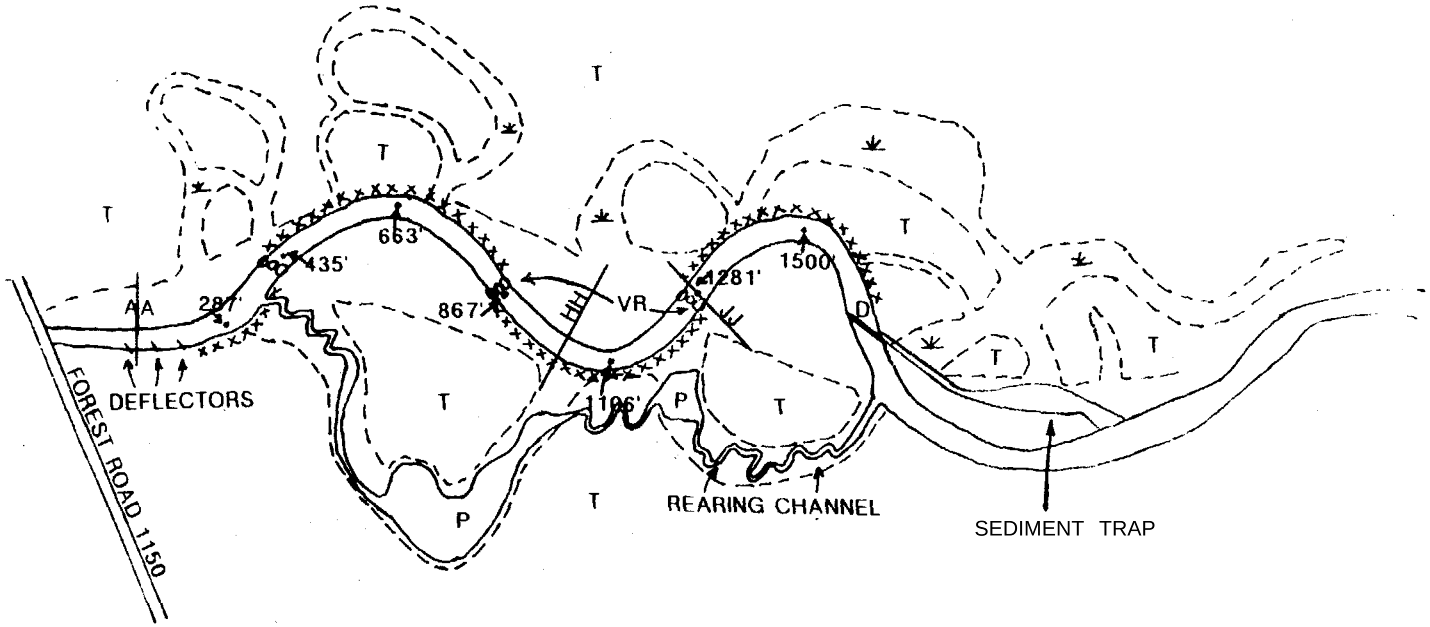


FIG 5 DESIGN CROSS SECTIONS



LEGEND

D DIVERSION BERM

T TERRACE

VR VORTEX ROCKS

xxx BANK REVETMENT

P POND

& CROSS SECTION HH

287' DISTANCE FROM BRIDGE ALONG PROPOSED CHANNEL

WETLAND BOUNDARY

DOWNSTREAM

WEST

100' 500

APPROXIMATE SCALE 1 3/28

5/91

FIG 6 DESIGN CHANNEL PLANVIEW

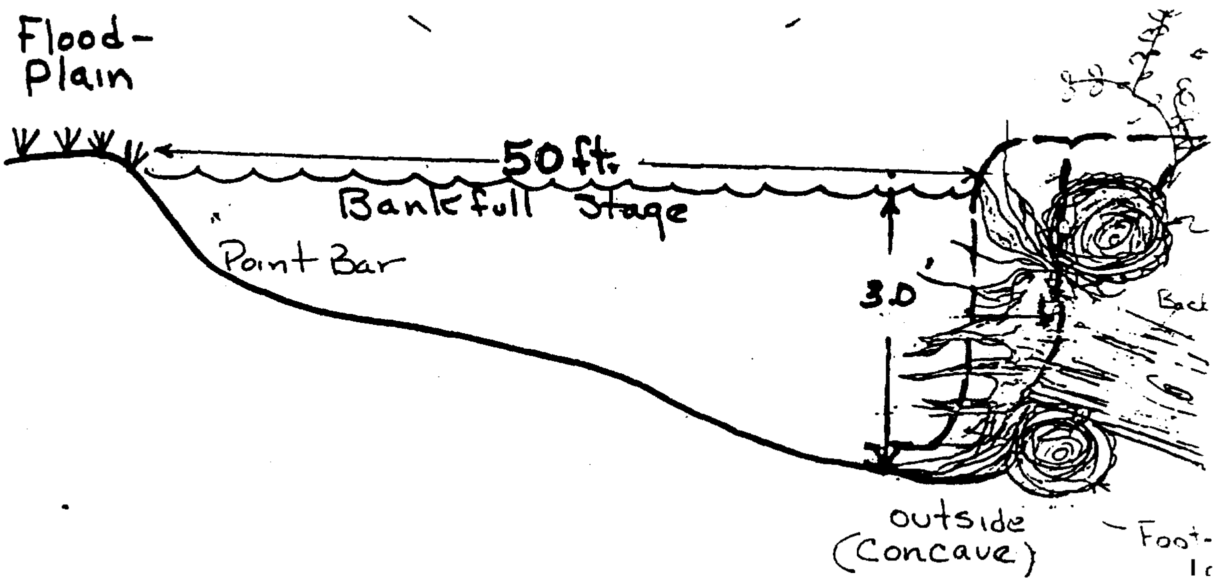
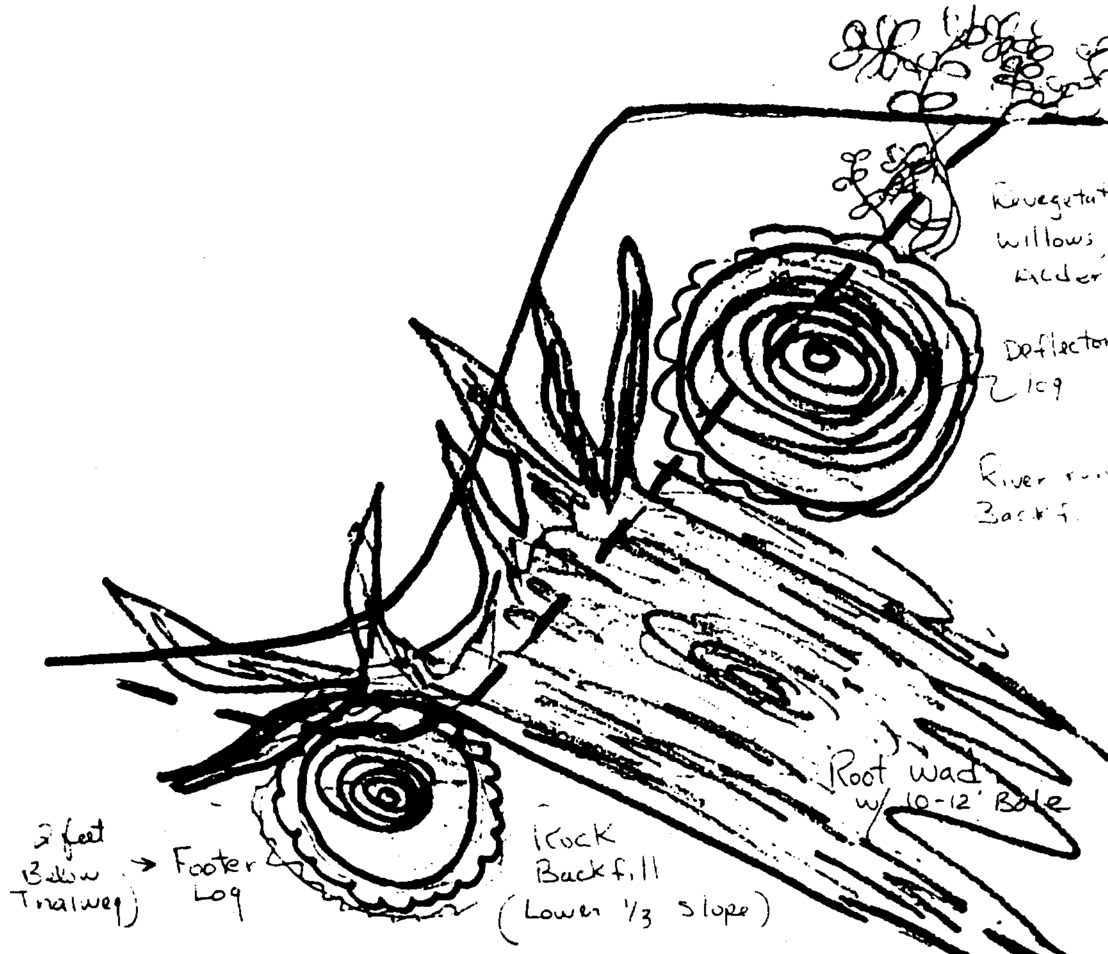
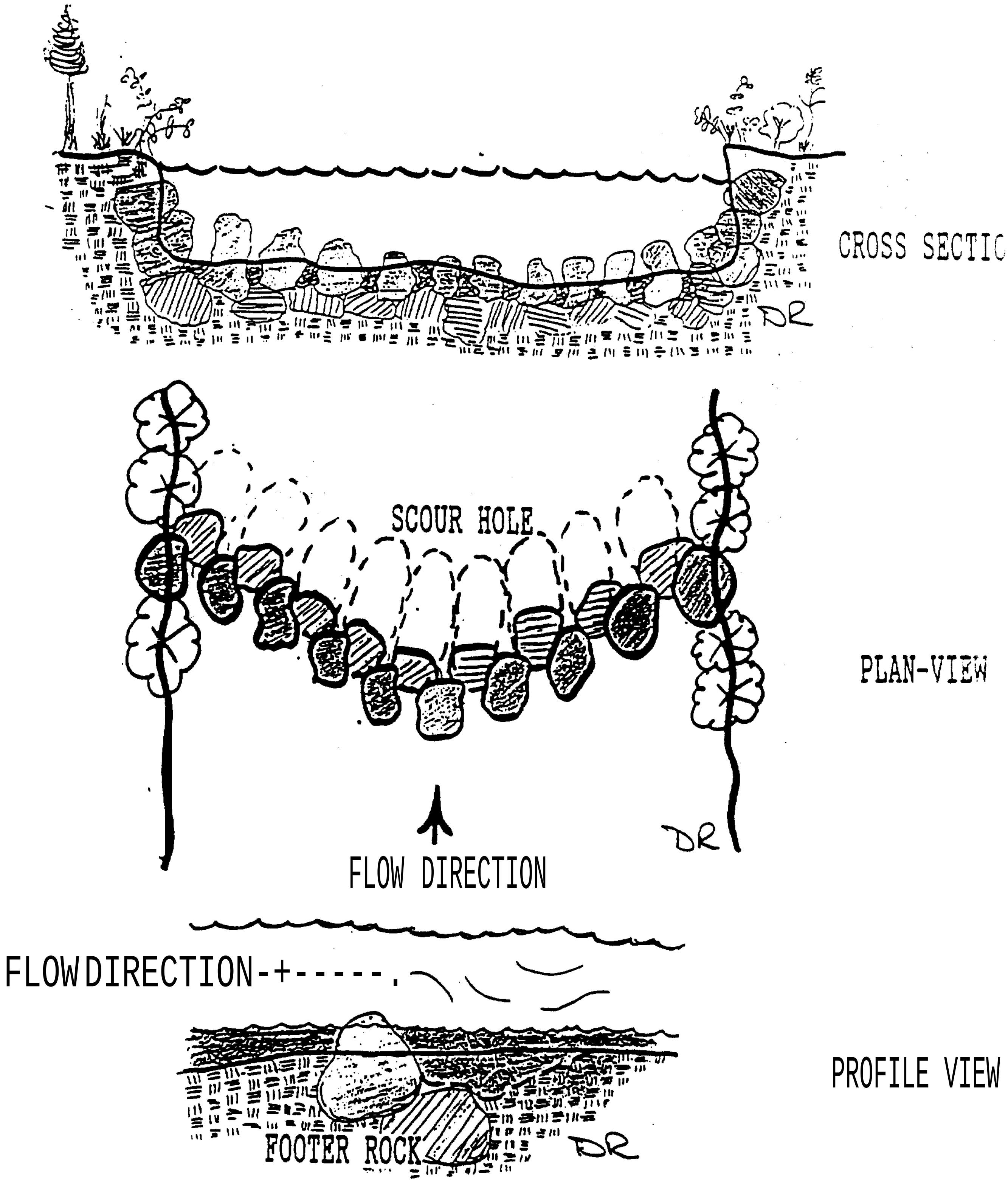


FIG 7 NATIVE MATERIAL REVETMENT

SKETCHES BY DAVE ROSGEN (1990)





SKETCHES BY
DAVE ROSGEN

DESIGN SPECIFICATION #5
"VORTEX" ROCK WEIR

ROSGEN & LEOPOLD
SHORT COURSE NOTES 1991

FIG 8 VORTEX ROCK STRUCTURE

Figure 8 shows a vortex rock structure that would be placed where the thalweg is to be located in the center of the channel, as for example at a crossover. The structure is a type of open rock weir designed to control thalweg location, maintain streambed elevation (ie. function as a grade control) and to create scour holes between the rocks for fish resting areas and cover.

Materials

Materials for 1450 feet of bank revetment were accumulated over the year before project construction. A total of about 180 rootwads with attached boles were used. These were donated by the USFS from a blowdown salvage area. The revetments, with an average height of 4.5 feet above thahveg elevation, required about 660 logs, 15 feet or more in length. About half of these were donated and transported by the Shearer Lumber Company's Elk City mill.

Approximately 80 3 to 5-foot boulders were used for the 9 vortex rock structures placed at the up- and downstream ends of each bend. An estimated 800 boulders were used to counterweight and wedge the logs in the lower parts of the bank revetments. Perhaps 200 of these were 3 to 4 feet in diameter, 500 were 2 to 3 feet and the rest were between 1 and 2 foot in diameter. These were all oversize rocks left at USFS or Shearer Lumber Company's rock pits after crushing operations.

About 120 cubic yards of pitrun rock were used as backfill. Approximate costs of transported materials are included in the cost breakdown in Table 2.

Table 2. Project cost estimates.

Rootwad/Log/Boulder Hauling	**$10,100**
Consulting/Expert Assistance	**$16,655**
Construction Equipment	$28,211
Other Materials (headgates, pumps, etc.)	$ 1,842
Total	**$56,808**

Donations Included:

Hauling assistance from Idaho National Guard and Shearer Lumber Co.
Volunteer planting (willow) from FS and IDF&G personnel and local residents.
Nursery services (grow lodgepole saplings) from Potlach Corp.
Volunteer planting (lodgepole saplings) by Kelly Creek Flycasters.

Note: USFS personnel salary costs are not included in this expenditures list.

Planning: NEPA, Permitting and Contracting

Since 1984, measures to protect, restore and enhance fish habitat in Red River have been done under the authority of a Decision Notice and FCNSI relating to the "Red River Fish Habitat Management Plan.' The Plan is consistent with the Nez Perce National Forest Plan (1987), and covered the fish habitat problems in the 1991 project reach. Because it did not envisage realignment of the river, however, a supplement to the 1984 Environmental Assessment was written for the current project, and additional public scoping was done in 1991. The supplement and scoping notes are available at the Red River Ranger Station in the Red River Restoration file (USFS filing system number 1950).

A permit to alter a stream channel was obtained from the Idaho Dept. of Water Resources and an Army Corps of Engineers 404 permit was secured. Phone or personal consultations were held with the National Marine Fisheries Service (for chinook salmon), the Idaho Dept. of Fish and Game, the US Fish and Wildlife Service, which required biological evaluations for impacts on the grizzly bear and grey wolf, and the Idaho

Dept. of Environmental Quality. Surveys to identify cultural resources and threatened, endangered or sensitive plants on the project site were also done and are documented in the 1950 file.

Contracts were let for rental of an unoperated excavator, and for an operated **6-yard,** rubber-tired front loader and D6 equivalent bulldozer, Contracts were awarded to Dave Rosgen, for on-site design review and construction assistance, and to Rusty McKee, to operate the excavator and construct the bank revetments and vortex rock structures, Mr. McKee has worked with Rosgen on most of his river restoration projects. and thoroughly understands the intricate construction requirements for the native material revetments and vortex rock structures.

Construction

During the plan-in-hand review, it became evident that it would not be possible to move the volume of dirt needed to realign the river as designed with the available equipment and time. The estimated volume of cut and fill material, which approximately balanced each other, was about 4400 yards, not including the revetment materials themselves. In addition to the other equipment, it would have required a scraper to move that amount of soil within the 2-week time frame.

For this reason, the project lay-out was revised to require much less excavation. The four bends were rounded and stabilized, the channel cross section was shaped, and the bend and crossover facet slopes were adjusted and stabilized. To create the **pool:riffle** slope sequence, the bends were constructed to **1/2** and the straight reaches to double the average reach slope. The result of this design adjustment was that reconstruction was aimed less at restoration of sinuosity than at stabilizing banks and restoring a longitudinal profile associated with a stable **pool:riffle** sequence. To ensure maintenance of the reconstructed long profile, in spite of the fact that sinuosity could not be fully restored, vortex rock structures were prescribed (Rosgen, on-site review, July 1991) at the head and tail of each bend, to function both as grade and flow direction controls. The sediment pond location was also changed so that the pond could remain as a permanent rearing pond, connected to the main channel by sinuous side channels. Figures 9 and **10** show the river plan view and longitudinal profile after the main channel and pond work were completed.

The construction sequence was as follows.

The sediment/rearing pond and its inlet and outlet channels were constructed.

The first diversion berm, to divert the river away from the first bend, was built. This diversion forced flow across the floodplain on the south side of the river just downstream of the Moose Butte bridge.

The vertical, eroding banks on the straight reach just downstream of the bridge were laid back and sodded with sod taken from the first bend excavations.

At the first bend, the bank was excavated back to its new alignment (about 15 to 20 feet), and the bank revetment was constructed.

A second diversion berm was built just below the first bend and lined with black plastic to minimize seepage. The first diversion berm was then removed and water was routed into the side channel

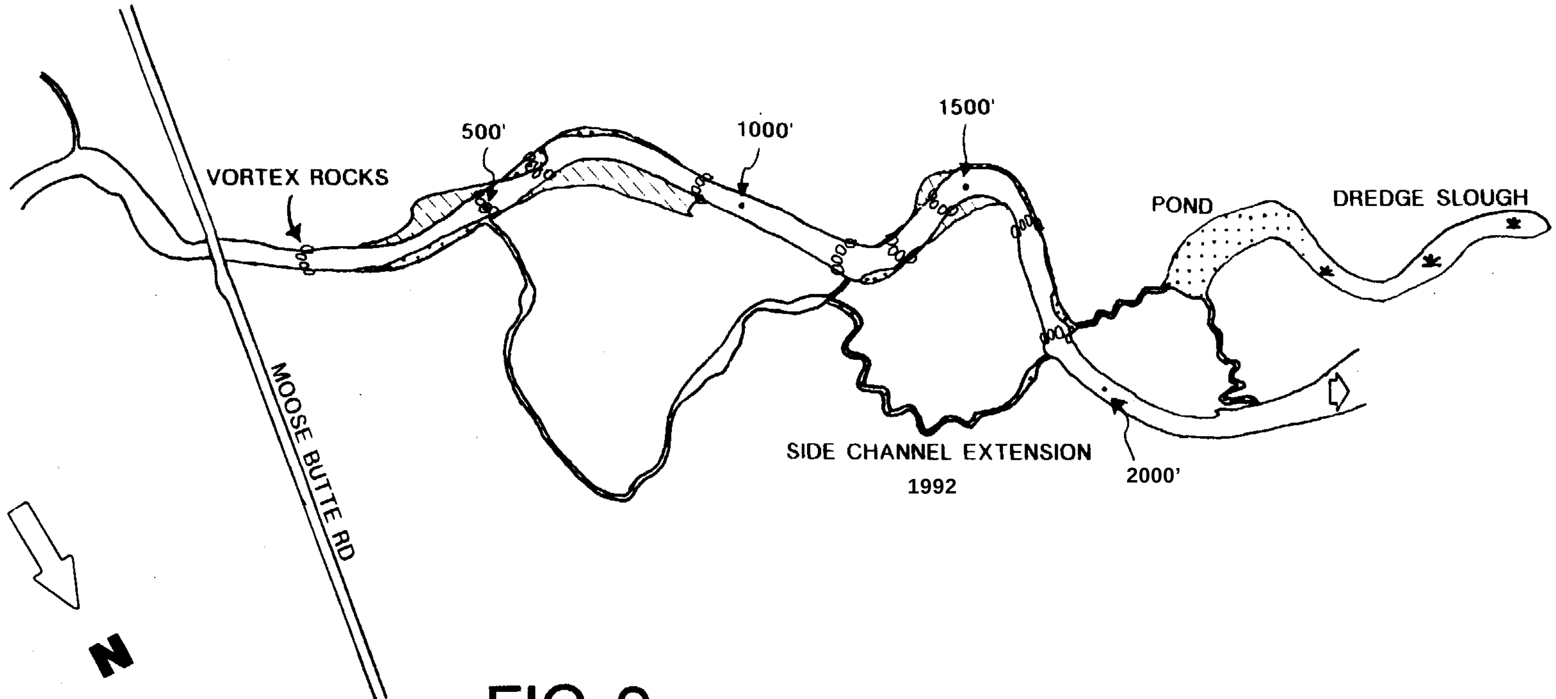


FIG 9

DISTANCES SHOWN ARE MEASURED ALONG CHANNEL FROM BRIDGE

POST PROJECT CHANNEL PLANVIEW

1991

RED RIVER AT RED RIVER RANCH

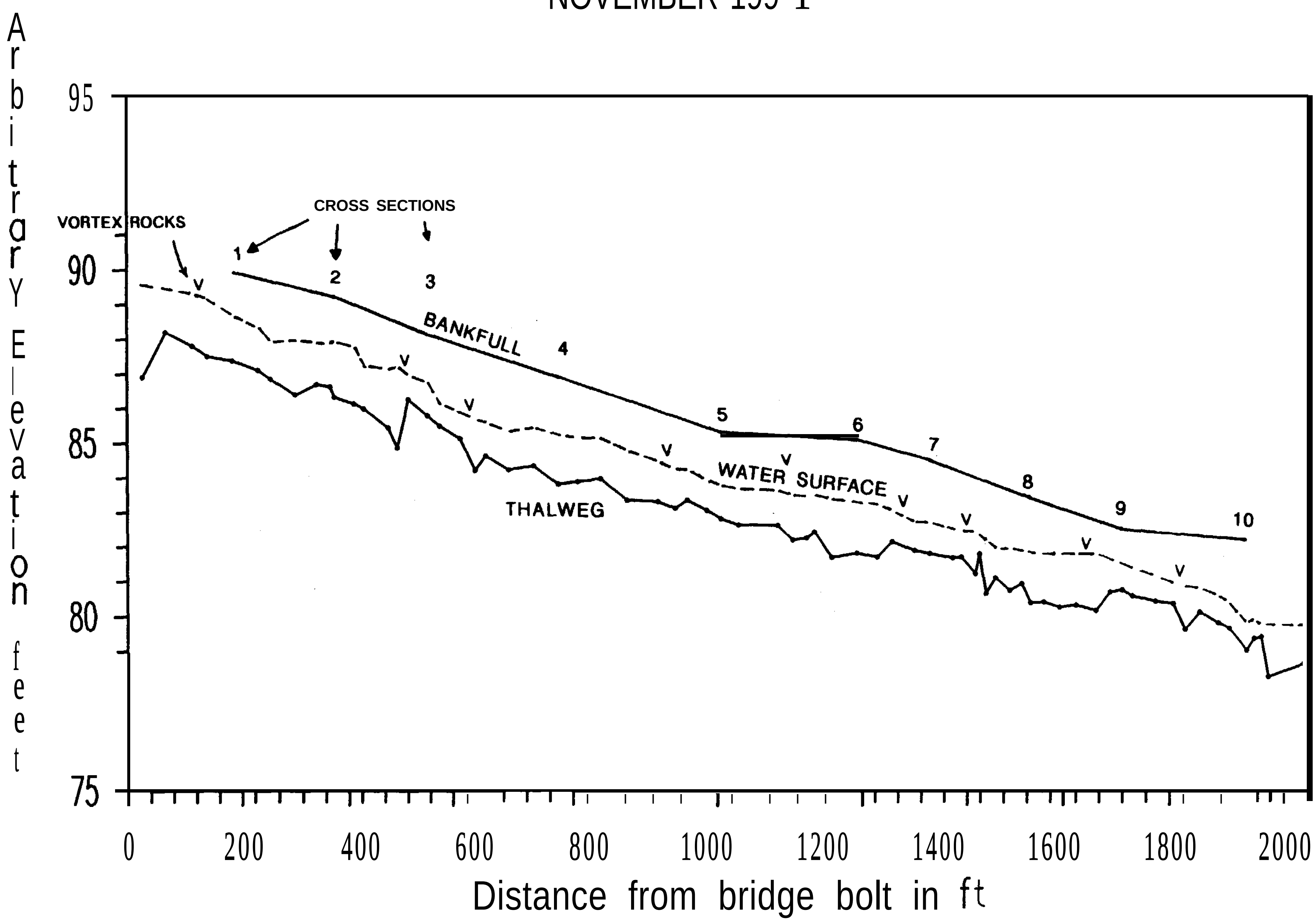
FILLS

CUTS

SCALE 1 3728

FIG 10 RED RIVER LONG PROFILE

NOVEMBER 199 1



at the second berm. This allowed the rest of the channel construction to be completed in relatively dry conditions. Seepage water from the construction area was routed through the sediment pond by means of a third diversion berm at the inlet channel.

At each bend, the bank was excavated back to the new alignment and the excess material was placed on the opposite point bar. Channel bed elevations were adjusted, and where necessary, banks on straight reaches were sloped and sodded. Revetments were constructed by the excavator as the loader and dozer worked on the downstream reaches, shaping, sodding and hauling materials.

A box headgate structure with wingwalls was set to control flow in the rearing pond inlet channel. Damboards used in these structures must be manipulated by hand to control inflow.

Both remaining diversion berms were removed.

The vortex rock structures were set in place, and the headgate structure for the upper side channel was installed.

Near the upstream end of the project, a dozer with a 6-way blade was contracted to reshape the channel and grade the floodplain. The first diversion had been through this area and it remained too wet to grade until a week or so after the other equipment had left.

Quite a bit of finishing work was needed after the major construction was finished: additional sodding on the side channel and pond banks, final grading of stockpile areas, seeding and mulching disturbed areas and general cleanup.

Figure 9 shows the post-reconstruction reach alignment, the rearing pond and the side channel that connects it to the river, and also identifies the areas that were excavated or filled. The upper side channel extension shown in this figure will be constructed in 1992. It will be an E4 channel about 1.5 feet wide and 1 to 1.5 feet deep and will include 2-3 rock grade controls near its outlet to the river.

Post-reconstruction channel widths and depths are given in Table 1.

Project Monitoring

The overall monitoring objective is to ascertain whether, in the medium term (10-20 years), the project achieves its goals of reducing bank erosion rates, improving fish habitat quality, and restoring riparian vegetation.

PROJECT *DESIGN MONITORING*

Photo Points: The most important and the simplest monitoring tool - repeat photos of the channel and riparian area from established photo points - will document any large channel adjustments. as well as the progress of riparian revegetation over time. These photos should be taken at least once every year during the late summer when the river is low and channel features are visible. Photo point locations are identified in Figure 11. 1990 and 1991 photos are filed at the Red River Ranger Station in permanent file 2630, Red River Restoration - Monitoring. Before and after photos from photo point 2 are shown in Figure 13.

Channel Surveys: Permanent monuments were installed in the fall of 1991 at the **endpoints** of 10 cross sections. Figure 11 shows their locations. These cross sections and the longitudinal profile (Figure 10) were surveyed in November of 1991. Average values for width, depth and cross section area are given in Table 1. These cross sections are different from those surveyed in October of 1990 before project construction (see Figure 12 for locations). Three of those that are oriented similarly are superimposed to compare pre- and post-project channel shapes in Figure 14. All survey data are filed in the 2630 monitoring file at the Ranger Station.

The monumented cross sections should be resurveyed in 1992 (after one runoff season), 2 or 3 years later (in 1994 or 1995), and again in 2001 or thereabouts. This will document any channel adjustments, major or minor, and will serve as a more quantitative basis for concluding whether channel stability has been achieved. As a matter of course, the surveys should be repeated if major channel changes are observed or indicated by the repeat photos,

Discharge and Sediment Load Monitoring: Figure 12 shows the location where three discharge and bedload measurements were taken in spring 1991.

Date	Discharge (cfs)	Bedload discharge (t/d)
4/9/91	153	3.6
4/16/91	127	0.3
5/15/91	390	10.5

In 1992, a staff gage was installed on the north-west abutment of the Moose Butte bridge. The stage-discharge curve will be established during 1992, and suspended and bedload samples will be taken weekly both up- and downstream of the project reach. Monitoring cross sections are located on Figure 11. The objectives of this effort are to:

1. relate discharge in the project reach to discharge at the Main and South Fork Red River gages so that future flood discharges that may affect the reconstructed channel can be estimated from gage data.

2. determine the amounts and particle sizes of incoming and outgoing sediment. In conjunction with the cross section resurveys, this will permit an evaluation of whether the reconstructed channel provides for sediment transport continuity. If incoming and outgoing rating curves and particle size distributions are different, it will provide early warning of possible future problems with aggradation or degradation, and a basis for designing solutions.

If it can be continued for several years, this monitoring effort will also characterize sediment yields in Lower Red River. It is the furthest downstream monitoring location on the Red River system, and the results may

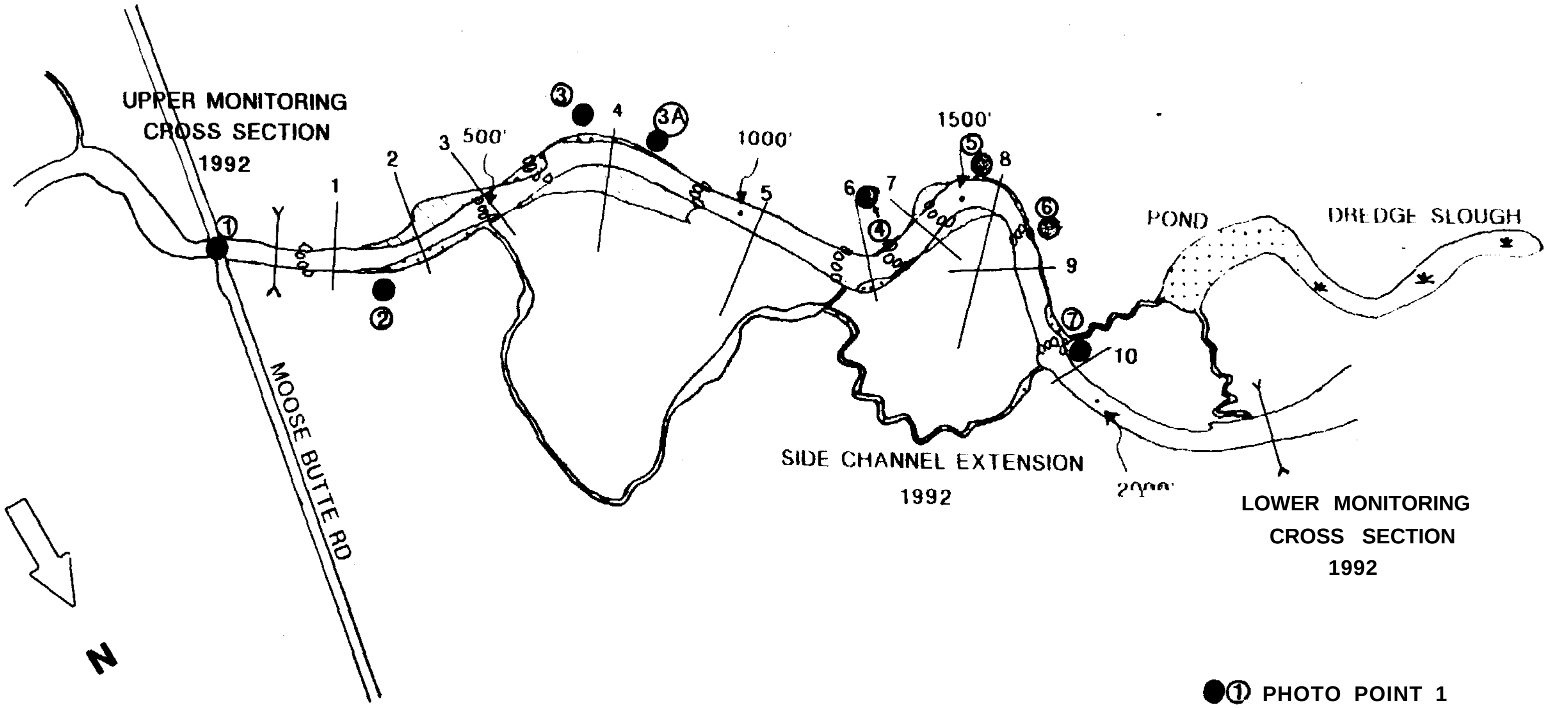


FIG 11

LOCATIONS OF SURVEYED CROSS SECTIONS **&** OTHER **MONITORING** STATIONS

NOV 1991

SCALE 1:3728

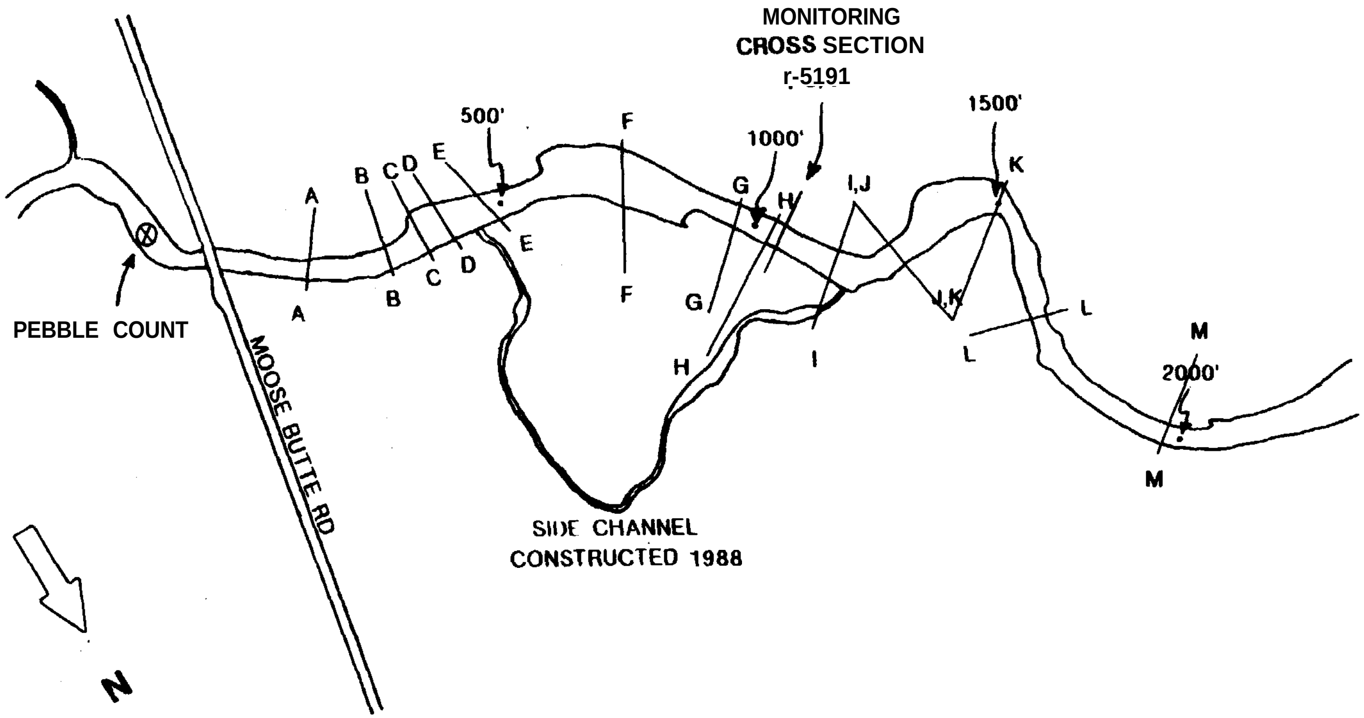


FIG 12

LOCATIONS OF SURVEYED CROSS SECTIONS & OTHER MONITORING SITES

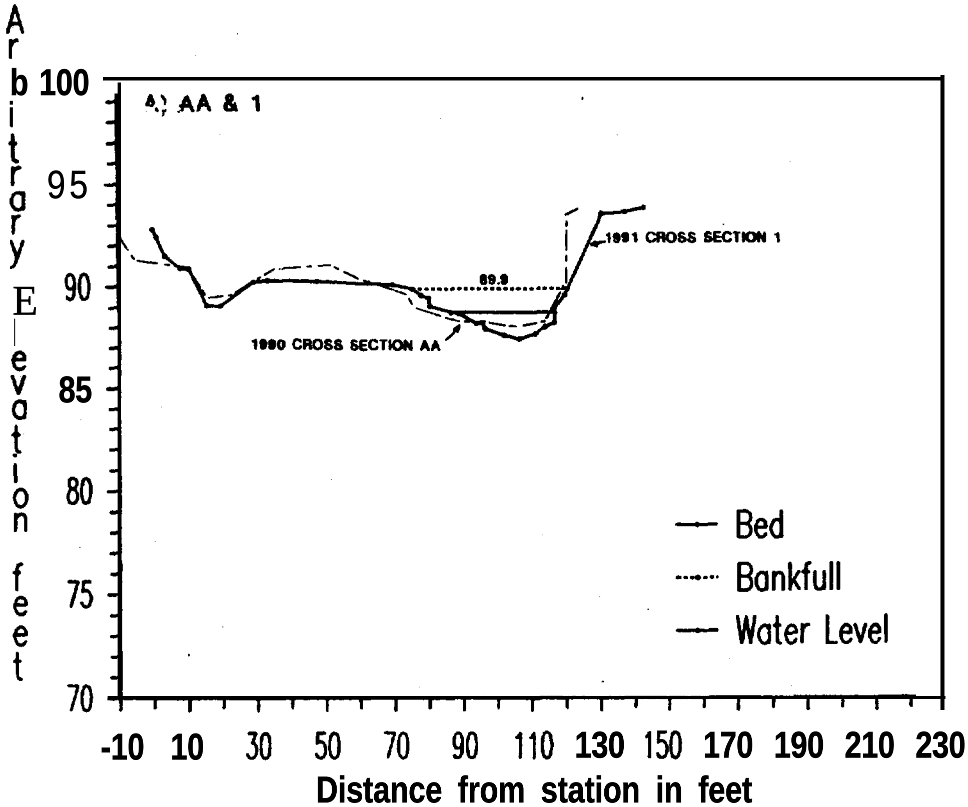
OCTOBER 1990

SCALE 1:3728

a) MARCH 1989 - BEFORE RESTORATION

b) SEPTEMBER 1991 - AFTER RESTORATION

FIG 13 VIEW FROM THE FIRST BEND UPSTREAM TOWARD MOOSE BUTTE BRIDGE (ROAD 1150).
PHOTOGRAPHS TAKEN FROM PHOTO POINT 2.



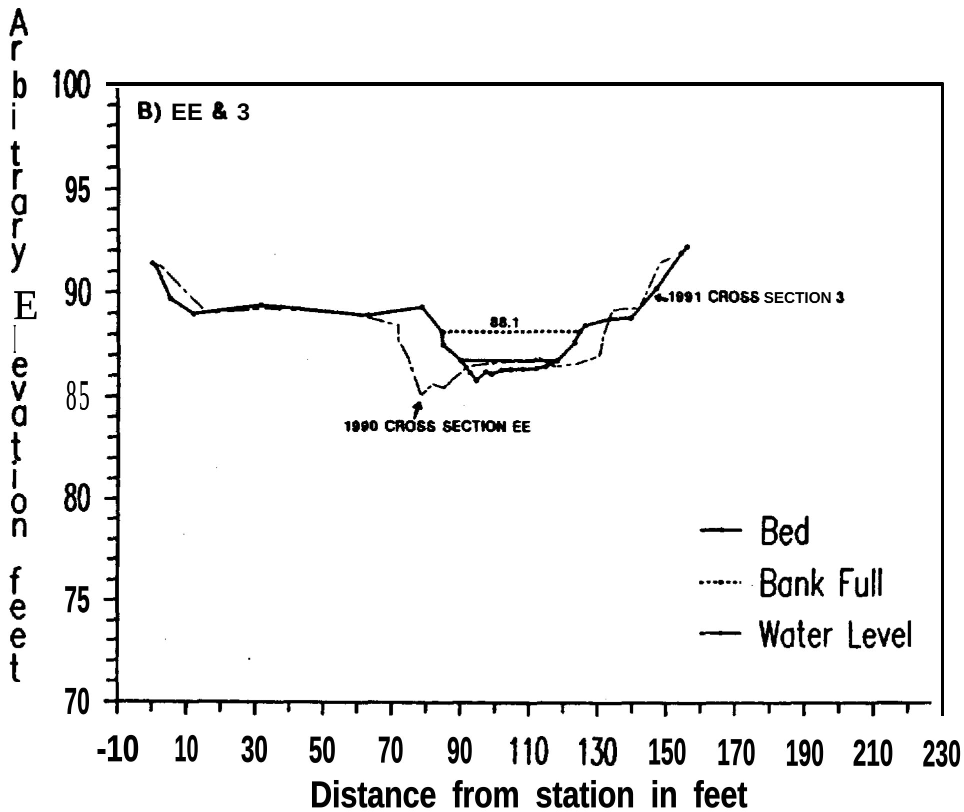


FIG 14 PRE- AND POST-PROJECT CROSS SECTIONS

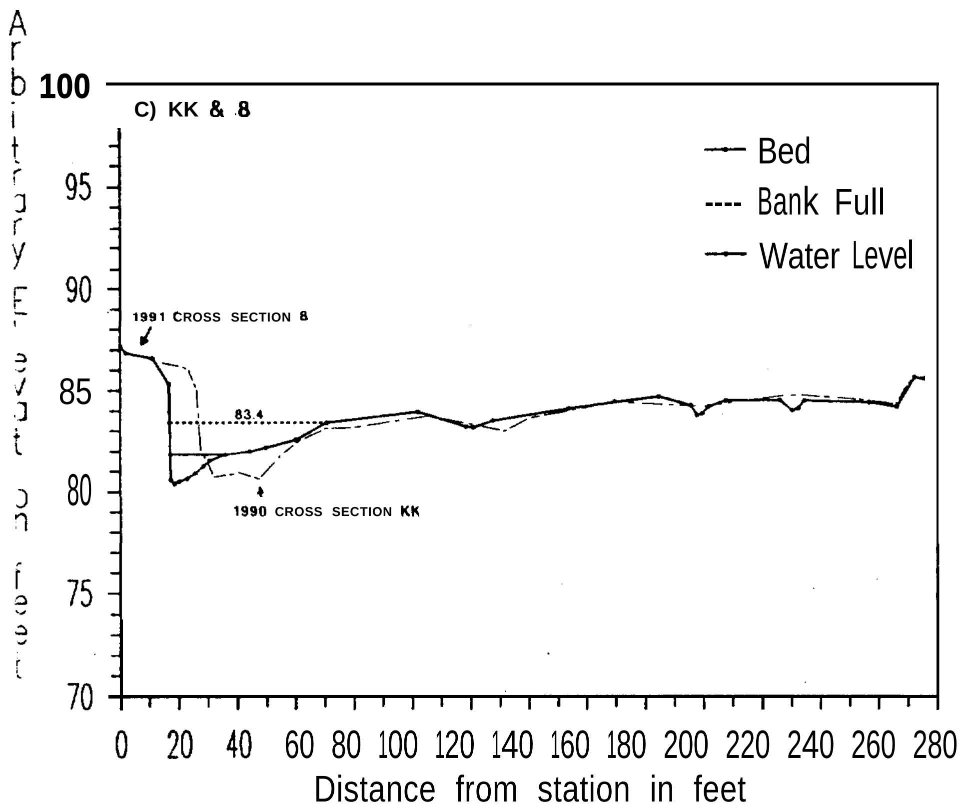


FIG 14 PRE- AND POST-PROJECT CROSS SECTIONS CONT.

SEE FIGURES 11 AND 12 FOR CROSS SECTION LOCATIONS assist biologists in identifying the precise nature of sedimentation problems affecting fish habitat in these lower spawning reaches. With the Main and South Fork gage data, these data may also be used to make a crude estimate of the validity of the Nezsed routing coefficients in current use.

Pebble Counts: A Wolman pebble count was done in April 1992 in a glide just above the Moose Butte bridge (see Figure 12 for location) to estimate pre-project bed material size distribution. D_{50} was 40mm (very coarse gravel), and D_{84} was 95 mm (small cobble). During the summer of 1992, pebble counts will be taken in the project reach at three locations to determine if and how bed material size distribution was altered by the project. These counts, and the count above the bridge, should be repeated when the cross section surveys are done to define any changes over time, These data should confirm the sediment load monitoring results and will assist biologists in assessing fish habitat quality and medium term trends in the project reach.

Vegetation Condition: In 1991, disturbed wetland areas on the Red River Ranch project were seeded with the following mix, recommended by the Idaho Dept. of Fish and Game, primarily for its value as cover and food for waterfowl:

Alkar tall wheatgrass	40%	
Oahe intermediate wheatgrass	20%	-- by weight
Delar small burnett	27%	
Ladak alfalfa	13%	

Non-wetland disturbed areas were seeded with a mixture chosen for its value as wildlife forage:

Timothy	33%
Smooth Brome	23%
Creeping Foxtail	3%
Intermediate Wheatgrass	41%
Alsike Clover	5%
White Dutch Clover	5%
Cicer Milk Vetch	20%

A map showing locations where each seed mix was used is included in the 2630 file at the Red River Ranger Station.

The range condition assessment procedure described in the USFS Range Analysis Handbook (section 321) will be used to document the recovery of riparian vegetation and to determine which species of those seeded succeed. Transects will be set up to cover distinct types of ground: floodplains, high streambanks and cobble fills such as that adjacent to the rearing pond. Observations should be made each time the cross sections are resurveyed, beginning in 1992. This monitoring effort will not indicate how well woody shrubs are reestablishing themselves, but the repeat photos should show this. Transect locations and data will be documented in the permanent 2630 monitoring file.

FISH HABITAT AND FISH DENSITY MONITORING

Introduction: During late summer of 1990, and prior to the implementation of the river realignment and bank stabilization project, stream habitat and fish population density surveys were conducted. The purpose of these surveys was to establish baseline conditions which could be used to evaluate project effects.

Methods: Stream habitat condition was estimated on a 1055 meter reach of Red River (Figure 2) using the Nez Perce National Forest basinwide survey methodology (Lanigan et al. 1990). This survey incorporates Hankin and Reeves's (1988) methods for estimating habitat areas and fish abundance, and habitat condition ratings developed by Platts et al. (1983, 1987) and Espinosa (1989). The habitat survey was completed in July 1990, and fish abundance information was collected in September 1990. Three experienced snorkelers identified and counted fish by species and size class.

Statistically significance differences (a = 0.05) among means were determined using ANOVA followed by Tukeys multiple comparison test (Zarr 1984). Habitat condition percentages were normalized using the arcsin transformation before being analyzed; percentage data are known to follow a binomial distribution rather than a normal distribution required for the application of ANOVA (Zarr 1984). Calculations were performed using a Hewlett-Packard 41CX calculator with a Stat Pac Module.

Throughout the results section means and standard errors are reported, except for fish densities where means and 95% confidence limits are reported.

Results: Total stream length surveyed was 1055 meters. Figure 15 is a display of the sequence of habitat units identified during the survey. Mean stream wetted width was 12.1 ± 0.35 m. Mean water depth was 28 ± 2.04 cm ($n=9$) for glides, 19 ± 1.00 cm ($n=10$) for riffles, and 50 ± 10.00 cm ($n=2$) for pools. Pools were significantly deeper than glides ($q=6.84$, $P<0.01$). Glides were significantly deeper than riffles ($q=5.01$, $P<0.025$). There were 801 m^2 of pool habitat, 7869 m^2 of riffle habitat, 4889 m^2 of glide habitat, 83 m^2 of alcove habitat, and 1540 m^2 of side channel habitat. Pool:riffle ratio was 18:82. Glides were included in the pool:riffle ratio as either pool or riffle habitat based on whether they were more riffle-like (shallow-with moderate surface agitation) or more pool-like (deeper-with little surface agitation).

Pool quality, a rating ranging from one to five (five being highest quality) and based on size, depth, and cover, was five for the two pools present in the surveyed reach. Instream cover, recorded as the percentage of the habitat unit that had cover originating from surface turbulence, instream vegetation, woody debris, or undercut banks, was low and averaged $5\% \pm 0.03\%$ for glides, $6\% \pm 0.07\%$ for riffles, and $19\% \pm 2.33\%$ for pools. Instream cover rating for pools was significantly different from riffles ($q=6.20$, $P<0.01$). Instream cover was similar for riffles and glides ($q=0.96$, $P>0.25$). Bank cover, recorded as the percentage of the habitat unit that had cover originating from overhanging vegetation or undercut banks was also low and was $3\% \pm 0.15\%$ for all habitat types. Bank stability, the percentage of the habitat unit lined with stable banks, was $70\% \pm 0.33\%$ for all habitat types.

During the survey the average cobble embeddedness was visually estimated to be 25%; this estimate is uncharacteristically low for Red River. However, the survey crew was inexperienced at collecting this parameter and probably underestimated cobble embeddedness. It is likely that cobble embeddedness was closer to 50%-70%. Cobble embeddedness measured using methods adopted from Burns (1984) at

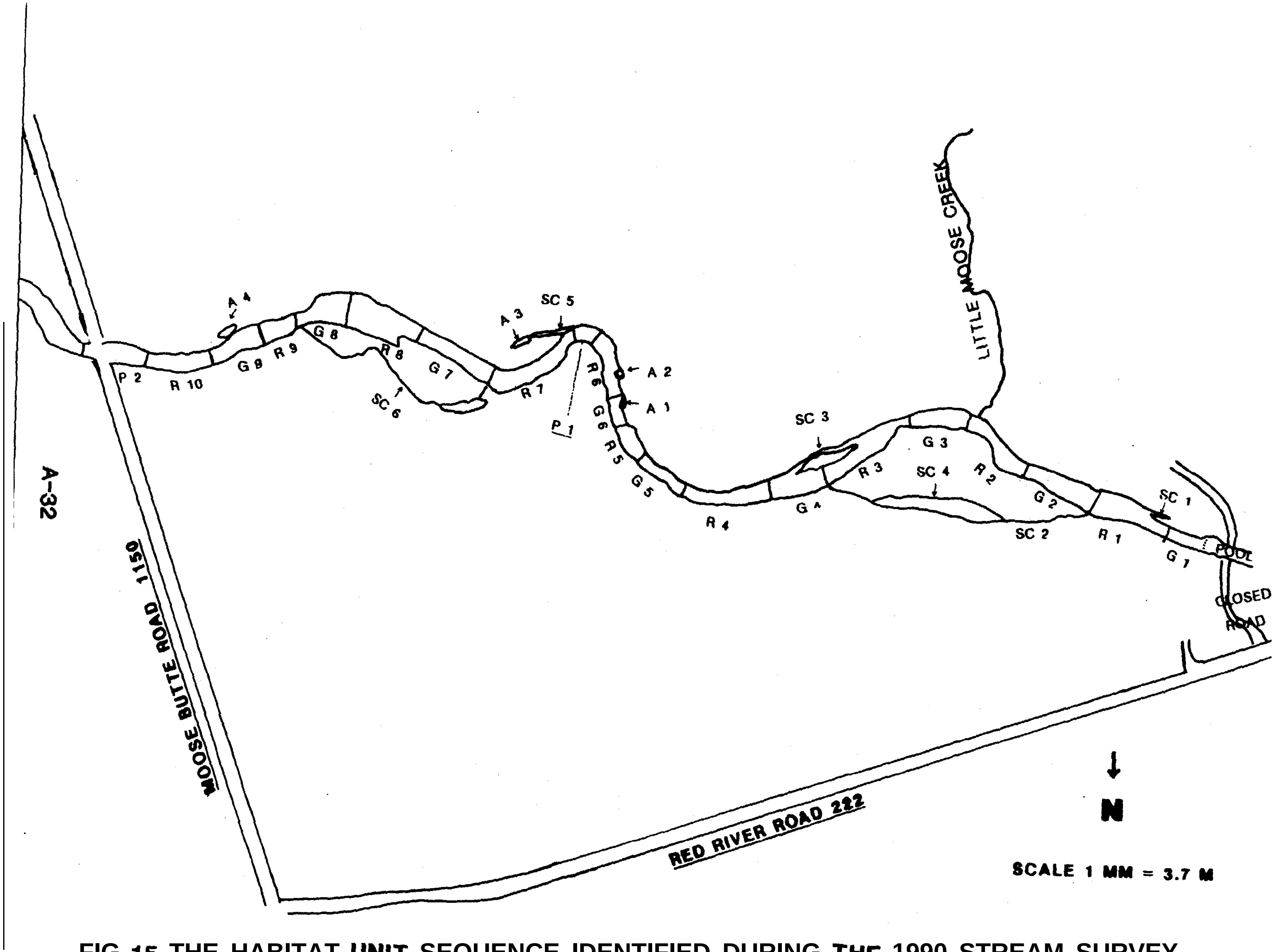


FIG 15 THE HABITAT UNIT SEQUENCE IDENTIFIED DURING THE 1990 STREAM SURVEY

a permanent Forest monitoring station on upper Red River (approximately 5 kilometers upstream of the project reach) had a mean cobble embeddedness of 51% in riffles and 71% in pools measured in 1989.

One piece of in-channel large woody debris and no riparian trees which could eventually contribute in-channel debris (potential woody debris) were recorded within the surveyed reach.

Fish densities weighted by habitat size and reported as number of fish per 100 m^2 ±95% confidence interval for each species were:

trout (<75 mm) 1.4±0.31,
rainbow-steelhead trout (*Oncorhynchus mykiss*) (75-127 mm) 0.1±0.002
rainbow-steelhead trout (>200 mm) 0.1 ±0.001,
chinook salmon (0. *tshawytscha*) (< 127 mm) 25±0.246
chinook salmon (> 127 mm) 0.1±0.003,
cutthroat trout (0. *clarki*) (75-305 mm) 0.1±0.002,
brook trout (*Salvelinus fontinalis*) (all sizes) 0.1±0.002,
and mountain whitefish *(Prosopium williamsoni*) (all sizes) 4.0±0.052.

There was 23.9 m^2 of steelhead spawning habitat (substrate sizes 0.6-l 0.2 cm) of which 4.8 m^2 was in fair condition and 19.1 m^2 was in poor condition. There was 19.1 m^2 of chinook spawning habitat (substrate sizes 1.3-l 0.2 cm), all of which was rated as being in poor condition. Condition is based on distance of spawning gravels from cover, size of the gravels, cobble embeddedness, and water velocity.

Discussion: Historical accounts and photographic records suggest that Red River, pre-European settlement, was a highly meandering stream with moderate width/depth ratio (approximately 25) and stable banks with deep rooted shrubs and grasses throughout its meadow reaches. Beaver activity was probably high and meadows probably flooded frequently at high flow. This condition contrasts sharply with the condition found during the 1990 stream survey.

Habitat diversity was found to be low during the stream survey. Factors contributing to this condition included low pool:riffle ratio (18:82), the lack of cover, in-channel and potential woody debris, and poor bank stability. Even though this is a meadow reach, some in-channel and potential woody debris are expected to occur. It is not unusual for meadow streams on the Red River District to have in-channel and potential woody debris densities of 2 to 20 pieces/l 00m. Debris jams and beaver activity in local meadow streams contribute in-channel woody debris in meadow streams with stable banks. Probably, increased width/depth ratio and low bank stability currently limits beaver activity in the project reach of Red River.

In relatively undisturbed meadow streams on the Red River Ranger District mean percent instream cover ranges from 20% to 40%; mean percent bank cover ranges 10% to 25%; and mean bank stability is greater than 90%. Red River where it flows through the Red River Ranch had much lower percentages for all of these habitat condition variables. The poor habitat condition found is a function of the land use practices which have occurred within and above this stream reach. Past grazing, mining, channelization, and high sediment loads caused by upstream watershed development, have resulted in a habitat condition characterized by low habitat diversity, lack of undercut banks, woody debris, overhanging streamside vegetation and low mean percent bank stability.

U.S. Forest Service targets for anadromous fish densities in third through fifth order streams are 30/100m², and 75/100m² for steelhead and chinook, respectively (Stowell and Espinosa, 1989). Anadromous fish densities in the project reach were well below this level. The primary cause for this is probably associated with poor smolt survival due to downstream dams; however, improvement in anadromous fish densities can be expected if preferred habitat types and cover were increased within the project reach. Hillman (1986) found that chinook fry densities were greatest in Red River close to cover in glides and the lateral and posterior margins of pools. He also found that age 0± steelhead used similar habitat.

Resident fish densities were also low. This condition was probably attributable to the lack of pool habitat, instream cover, and high cobble embeddedness which limit over-wintering and spawning habitat, as well as appropriate summer feeding sites. Bisson et al. (1982) found that age 1+ trout density increased as cover increased. Harmon et al. (1986) state that salmonids prefer main channel, near shore, and side channel habitats with large woody debris. Age 0+, 1 +, and 2+ cutthroat trout were found in pools with woody debris; and age 0+ and 1 + steelhead were found in riffles with woody debris (Bisson et al. 1982). Research has established that increased percentages of fine sediment reduces the quality of spawning habitat by reducing intragravel survival of embryonic salmonids (Marcus et al. 1990).

Conclusion: The 1990 survey was conducted to document baseline conditions which could be used to evaluate project effects. In late summer of 1992, the Nez Perce National Forest basinwide survey should be conducted on the project reach. These data should be compared with that collected in 1990 to assess project effects on fish habitat and densities throughout the project reach. Additional surveys, at periodic intervals (3-5 years) should be conducted to assess the long term effectiveness of the River Realignment and Habitat Improvement Project.

1992 Work Program

The upper side channel will be excavated in the summer of 1992. A four-wire steel and wood post fence will also be constructed, and 250 lodgepole pine saplings will be planted. The trees will be planted densely around the pond to provide shade and, later, debris.

Further attempts will be made to fill the spaces on either side of the upper side channel headgate structure. Currently two large spaces exist along either side of a log in the bank revetment on the downstream side of the headgate, and they are continuing to erode and enlarge. At the downstream headgate structure, low-flow water level in the main river is too low, even with the vortex rock control, to maintain an adequate flow in the side channel. Because of rapid percolation in the pond, flow in the pond outlet channel could not be maintained in 1991. Some of the gaps between rocks in the vortex rock structure will be plugged to further raise the'water level there.

A post-project stream habitat and fish density survey should be conducted in late summer 1992 and compared to similar data collected in 1990.

Summary

The Red River Ranch segment of Red River was a typical example of a channel and riparian area degraded by dredge-mining, streambank grazing and higher-than-natural sediment loads caused by watershed development. The most significant fish habitat problems were lack of habitat diversity, especially pools, and very low in-stream cover. The approach taken to improve fish habitat condition differed from previous work at Red River; it attempted to restore habitat diversity by realigning the river to a near-natural meander pattern rather than simply adding pool and cover creating structures (such as log weirs and large boulders) to a non-equilibrium channel.

The reconstruction project stabilized about 1500 feet of 4 to 6-foot high eroding banks, adjusted the longitudinal profile to one typical of a stable pool:riffle sequence, shaped the channel, and controlled the thalweg location by placing vortex rock structures. Width:depth ratios were decreased by 14%, and average maximum depth increased by 0.5 foot. Instream cover was provided by native material bank revetments and vortex rock structures. Additional juvenile rearing area was created by construction of ponds and side channels.

In the long term, in-stream cover and bank stability will tend toward natural (ie. pre-European settlement) levels as deep-rooted shrubs and trees, which are being planted on the streambanks, are allowed to grow protected from stock browse. Because the riparian exclosure will not exclude wildlife and because growth rates are slow in the Red River area, it will probably take 10 to 20 years to recover the cover and root strength present under natural conditions. As the riparian vegetation reestablishes its natural density and forage value, beaver will no doubt move into the area. Whether their impacts can be tolerated will depend on when they arrive (ie. how far the riparian vegetation has progressed toward full recovery) and on whether natural vegetation has been reestablished on other reaches of the river. If Red River Ranch remains the only meadow reach in Lower Red River with a protected riparian area, and if beaver concentrate here to such an extent that they decimate the vegetation, some may have to be trapped and moved.

Long term success of the reconstruction project in improving fish habitat quality and channel stability should be monitored, as outlined above, especially since the ideal meander pattern was not achieved. As the Forest Service begins to place more emphasis on restoration, it is likely other similar projects may be proposed. We believe this project can be a valuable demonstration and training area, and therefore we strongly recommend the monitoring effort be funded and continued.

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